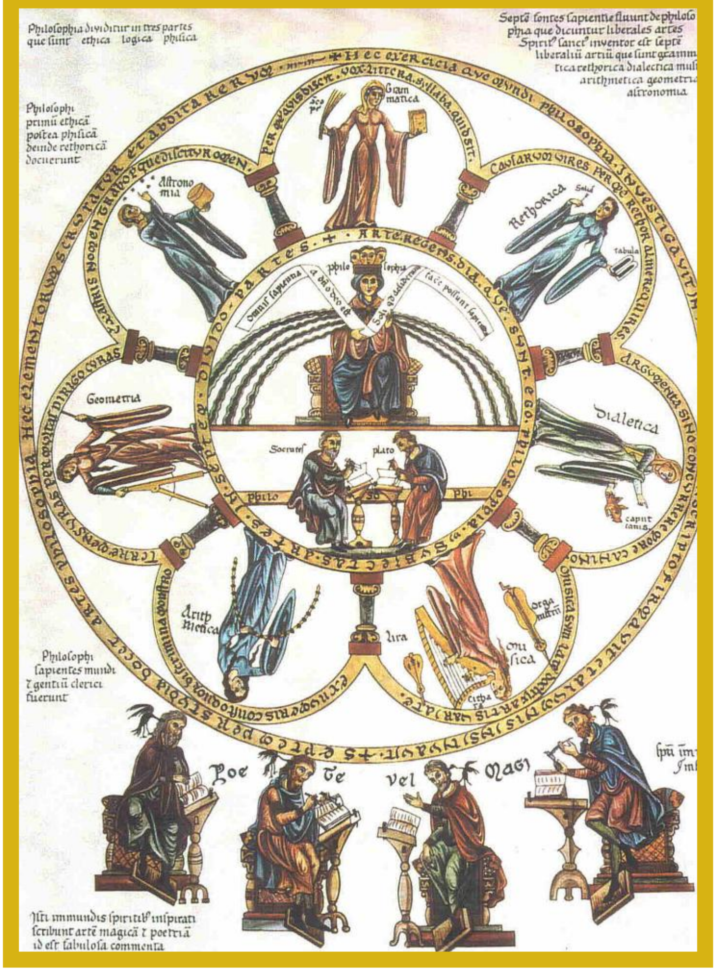
A Study of the Seven Liberal Arts and Sciences in Freemasonry



by
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Their origins, their Masonic relevance and how they are applicable in modern life.

Foreword.

When I started this project, I had no idea where it would lead or what it would look like if I ever finished it.

Why I chose The Seven Liberal Arts and Sciences, I will never know, but included in them were subjects I had studied, subjects I was interested in, and others were a complete mystery. To give you an example; when I started on Mathematics and Geometry I wondered what I would write about, then after I had started and really researched the subjects, I was amazed at the interesting and informative story that unfolded, so much so that they have become a major theme throughout the paper.

However as I dug deeper, the material I had gathered, became more complex, and I realised that there inextricable links between the subjects which I had never considered before. I would investigate a certain aspect of one, only to find that it impacted on others. The Fibonacci numbers is a fine example of this and before long I was fascinated with what I was discovering.

The point of the paper is, I hope, to give others the information about a very interesting subject in Freemasonry without the hundreds of hours of tedious research I have undertaken. Some may find it tedious because they already know a considerable amount about the subjects but I have deliberately aimed the book at the Entered Apprentice who knows nothing or very little, however, I hope that to the well informed I have found some interesting facts and stories that will justify the reading.

Firstly I want to assure the reader this not a work that I have devised alone, I consider myself a researcher and collector of information, who then takes that information and tries to put into an interesting and easy to read format. I have taken many other people's ideas and work and woven them into the simplest and most interesting way possible. I have tried to personalise it as much as possible in making comments and observations on the matters before me.

The information comes from a huge resource and I have tried to verify the facts, as much as possible, however I was not always successful, due to the volume of the work, it was nearly impossible, so I kept out what I was unsure of. This does not mean that there are not errors or misconceptions in the work and for that I sincerely apologise.

I do hope you enjoy what I have written as much as I have enjoyed writing it.

Fraternally yours,
Donald Fenwick.
2016.

To start we must examine The Seven Liberal Arts and Sciences as an entity.

Some would say that the ritual work of the Lodge is the most important part and that lectures on different aspects of Freemasonry are just a fill in, so I want to give you some food for thought.

I want to take you back to the middle ages, to the basement of a Cathedral under construction where after a hard day's work the stone masons gather in their 'Lodge' to continue their training. There are the Master Masons, the Fellows of the Craft and the entered apprentices. By the light of flickering candles they are there to study what they call the Seven Liberal Arts and Sciences. They cannot call it schooling or education as those words don't even exist. They call it by a name that actually predates the birth of Christ. First they would divide into their different sections, the entered apprentices with a Master Mason in charge, the Fellows of the Craft, with a Master Mason in charge and the other Master Masons in the third group. Then they would go over the day's work discussing any problems correcting any errors and giving a lesson on what was happening tomorrow or something new that they were attempting in the future. Each group doing it to the level of their proficiency. Then would come the more general education examining their proficiency in the "Liberal Arts and Sciences". They possibly did not cover the subjects as we know them but general knowledge was very important to them and, as we shall see later, they regarded education as an integral part of their craft.

So first we are going to look at the Origins of the Liberal Arts and Sciences, their Masonic relevance and how they are applicable in modern life, but I would like to start with a short examination of what we know as education. If we are to speak of "Masonic education," it is really unnecessary, because, Freemasonry is education, it contains moral instruction, spiritual enlightenment and intellectual growth in its very being, so that a man may come to know - and improve - himself. But this isn't supposed to be the only activity; Freemasonry is also a brotherhood. Together the brethren seek "that which was lost."

What was lost? Truth.

It is that search after Truth that makes Freemasonry different.

Freemasonry's teachings intentionally addresses the fundamental and perpetual curiosities of man, so it can be said that it is education without limit. Truly any field of study or discipline connects somewhere with Freemasonry's path of learning, and much of Masonic teaching, coincides with the Humanities. Masonry reveals itself through ritual. These centuries-old ceremonies are a framework, or more accurately, a map that each Freemason may follow in his search for Truth.

To summarize just one aspect of this process; as an Apprentice, the newly initiated Mason, is taught to subdue his passions while letting the Four Cardinal Virtues guide him toward candid self-awareness.

Next, as a more experienced Mason, the Fellowcraft, is shown the Seven Liberal Arts and Sciences: **Grammar, Rhetoric, Logic, Arithmetic, Geometry, Music and Astronomy** just as were the great thinkers who gave Western civilization its Renaissance, Reformation and Enlightenment, with all the culture it contained. A proper understanding of the Arts and Sciences empowers the Mason to make his mind the rational master of his primal Five Senses of hearing, seeing, feeling, smelling and tasting.

In the Third Degree of Freemasonry, the Master Mason is sufficiently aware of his place in the universe so as to fear no danger, not even death itself. Ultimately, upon exiting this earth for the final time, the Master Mason goes confidently to the Grand Lodge above, knowing that there is no sting of death and no victory of the grave, but only eternal life.

To digress, just a little, during my career in the Corporate world, I was privileged to teach Business subjects at evening classes within the TAFE system for some twelve years, but before I could teach I had to be taught 'how to teach and how people learn' and one of the greatest things I learnt from that was "to research and discover" if you want to be an expert on a subject you have to go on a voyage of discovery. So if you want to know what Freemasonry is really all about you have to go on a voyage of discovery. To get started, think about what you most desire to know about Freemasonry, and then find the answers which may come from quite unexpected sources. Naturally the internet delivers limitless information, but - even as with books - one must exercise discriminating choice. Again, let the ritual be your map. Choose an unfamiliar word, an odd phrase, a seemingly antiquated idea. Then define it, identify its Masonic significance and apply that meaning to a broader context of how it could benefit others; and then translate that idea into your own words so that you take possession and internalize it. Once it is yours, it is there as a tool for use in your growth, and it's there for good.

Education is interwoven in Freemasonry it predates modern Masonry itself. In the Old Charges - the dozens of manuscripts penned over the course of more than three centuries prior to the start in 1717 of the Masonic Order we know today - are found clear procedures on how new members of the building trade were to be schooled in their craft over long spans of time. In the Halliwell Manuscript, believed written in the 14th century and the earliest of these documents, are found the "Fifteen Articles for the Master Mason,"

Clearly the importance of education in the building arts is indisputable.

An interesting observation: The funny-looking cap people wear at graduation is called a mortarboard. It takes its name from the board Mason's used to hold their mortar when building Cathedrals and Castles and even Universities. At first only holders of a Master's degree were allowed to wear them showing the very significant connection higher education had with the masons' craft.

Today Freemasonry's instruction is presented in allegory and symbolism, but the education is no less crucial to the Speculative Mason's life. Tragically few seem to understand or want to understand, and this power goes neglected in the daily realities of contemporary Masonry. We can restore Masonic education to its rightful place as the paramount purpose of Freemasonry: to labour together in replenishing the "common stock of knowledge" in our pursuit of Truth.

The first mention of the Liberal Arts and Sciences is in the first Degree where the newly initiated Brother is urged to devote a portion of his leisure hours to the study of such of the liberal arts and sciences as may be within the compass of his attainments and to make a daily advancement in Masonic knowledge. In the Second Degree Tracing Board there is a fleeting reference to the Seven Liberal Arts and Sciences; it refers to the winding staircase, consisting of three, five, seven or more steps in the Temple and goes on to say that the seven steps allude to the seven liberal arts and sciences, nothing more and nothing less but like so much in the Masonic ritual, in these few simple words is hidden a wealth of knowledge and understanding. While to our ancient brethren aimed at a blending of all knowledge, the modern freemason can apply to the seven liberal arts and sciences a special and appropriate metaphor for a life of self-improvement and mental growth. This goal is symbolized in our lodges by the rough and perfect ashlars and by the Masonic agenda of taking a good man and making him better. *-Source: An article by Stephen Dafoe -*

Masonic teaching encourages us to contemplate and learn from the seven Liberal Arts and Sciences. At some point in our Masonic careers most of us will ask ourselves why is it that we find these seven specific areas to be more relevant than other disciplines, say geography or chemistry, or other forms of artistic expression, such as dance instead of music? and why would the study of music or astronomy make me a better Mason?

- Why seven arts, and not six or eight or twelve?
- Why do these arts always seem to be presented in a specific order, and are they interdependent upon one another?
- Are they equally important?
- And where do they come from?

These are the questions we are going to attempt to answer because without the answers to these questions it is impossible to fully appreciate the importance and beauty of the Liberal Arts and Sciences in a Masonic context. To expand our Masonic knowledge, as we are instructed, and to truly value these arts, we must make an effort to seek answers. And as the Liberal Arts and Sciences have been so significant for the progress of human knowledge over the last twenty or so centuries, that, once we find these answers, they will become a foundation for our understanding of the Craft and our own place in history.

The seven arts are composed of two families containing three and, respectively, four arts, this “3+4” structure is critical to understand how these arts complement each other.

Why was the term *“Liberal”* used to describe the arts and sciences?

Those who were slaves or not completely free would never receive a full education, therefore the curriculum was named the “Free” arts and sciences – *Liber* meaning free in Latin, the same root used in the word Liberty. Alternatively, we could also consider that once one achieves such level of education he would be free from the chains of ignorance and allow a person to govern his own life, ‘know thyself’ being a critical part of the learning process, instead of being governed by mere circumstance.

In fact, **Zosimo of Panopolis**, a 4th century Egyptian philosopher operating from Alexandria writes: *"That the spiritual and intellectual enlightenment could allow us to become free from fatalism, that is our fate is already written and there is nothing we can do about it; and from the power of the stars over the fate of men, that is astrological or zodiacal influences, which were accepted as a fact at that time".*

The learned man is a free man, liberated by the sciences.

The starting point in our search will be to review what are these seven arts and what they teach. As a Fellowcraft Mason we are made aware of the importance of the liberal arts and sciences, of which there are seven; namely, Grammar, Rhetoric, Logic, Arithmetic, Geometry, Music and Astronomy. Unfortunately few Freemasons today take this instruction with any degree of seriousness and make no further effort to examine the nature of these arts. We are indebted to the Scholastic philosophers of the Middle Ages for the classification by which they distinguished the seven sciences then best known to them. In the metaphorical spirit of the age in which they lived, they called the two classes, into which they divided them the ***trivium,*** or meeting of three roads; and the ***quadrivium***, or meeting of four roads; calling grammar, logic, and rhetoric the *trivium* and arithmetic, geometry, music and astronomy the *quadrivium*. These, they styled the seven liberal arts and sciences, to separate them from the mechanical arts which were practiced by the handicraftsmen. The liberal man, *liberalis homo,* meant, in the Middle Ages, the man who was his own master - free, independent, and often a nobleman.

Mosheim a German Lutheran theologian who founded the pragmatic school of church historians, which insisted on objective, critical treatment of original sources; when speaking of the state of literature in the eleventh century, uses the following language: *"The seven liberal arts, as they were now styled, were taught in the greatest part of the schools that were erected in this century for the education of youth. The first stage of these sciences was grammar, which was followed successively by rhetoric and logic. When the disciple, having learned these branches, which were generally known by the name trivium, extended his ambition further, and was desirous of new improvement in the sciences, he was conducted slowly through the quadrivium, arithmetic, music, geometry and astronomy to the very summit of literary fame."*

The Freemasons [1] of the Middle Ages, always anxious to elevate their profession above the position of a mere operative art, readily assumed these liberal arts and sciences as a part of their course of knowledge, thus seeking to assimilate themselves rather to the scholars who were above them than to the workmen who were below them.

Hence in all the Old Constitutions we find these liberal arts and sciences introduced at the beginning as forming an essential part of the body of Masonry. Thus, in the Lansdowne manuscript, whose date is about 1560, these sciences are thus referred to:

"We minde to shew you the charge that belongs to every treu Mason to keep, for in good Faith if you take good heed it is well worthy to be kept for A worthy Craft and curious science, - Sirs, there be Seaven Liberall Sciences of the which the Noble Craft of Masonry is one."

And then the writer proceeds to define them in the order which they still retain. It is noteworthy, however, that the order must have been changed; for in what is probably the earliest of the manuscripts - the one edited by Mr. Halliwell - geometry appears as the last, instead of the fifth of the sciences, and arithmetic as the sixth. It is not therefore surprising that, on the revival of Masonry in 1717, these seven liberal arts and sciences were made a part of the system of instruction. At first, of course, they were placed in the Entered Apprentice Degree, that being the most important degree of the period, and they were made to refer to the seven Masons who compose a Lodge. Afterwards, on the more methodical division of the degrees, they were transferred to the Fellow Craft, because that was the degree symbolic of science, and were made to refer to seven of the steps of the winding stairs, that being itself; when properly interpreted, is a symbol of the progress of knowledge, and there they still remain.

From Mackey's Masonic Encyclopaedia.

[1] The questions of when, how, why and where Freemasonry originated are still the subject of intense speculation. The general consensus, amongst Masonic Scholars, is that it descends directly or indirectly from the organisation of Operative Stone Masons. There is a record in 1646 where Elias Ashmole was made a Freemason in Warrington, Lancashire and the event was recorded by Colonel Henry Mainwaring. This is the first evidence of the invitation of an English Speculative Mason but one must consider that non Stone Masons, being there, that Speculative Freemasonry had occurred before that date. Source: *United Grand Lodge of England in the History of Freemasonry*. (Because of this information, I have continued to use the term Freemason where I found it in the "Middle Ages").

In the Ancient world the Liberal Arts and Sciences consisted of grammar, rhetoric, dialectic, arithmetic, geometry, music, astronomy; at least, the standard histories of education list them thus, though it is doubtful if Greek and Roman Schools rigidly adhered to that list or to its classification the Athenian schools of a certainty did not, because Aristotle and his successors taught zoology; neither did the schools and universities which were built in Europe after Charlemagne for the university at Salerno specialized in botany; the one at Cologne, in stenography and bookkeeping; one at Paris in law; and so on. The Medieval Freemasons were so devoted to the Liberal Arts and Sciences that, when the author of the first of the Old Charges included in the pages of the histories of the world, then being circulated in manuscript form, the grounds on which a Charter had been given to the Fraternity, he gave prominence to an old legend about two pillars on which the *"secrets"* of the Arts and Sciences had been preserved through Noah's Flood. This close and boasted connection between Operative Freemasons and the Arts and Sciences has long been a puzzle. Masons did not teach their apprentices each of the seven subjects, so why should a Craft of workmen boast of possessing what belonged to but a few universities? Boast they did because, they considered themselves apart and above the populace, which was illiterate. Even the clergy was uneducated. And among the prelates only a few could read and write. The majority of the kings, princes, and upper nobility knew so little about books or studies that they almost knew nothing; even as late as 1700 Louis XIVof France, the Sun King, the Grand Monarch, could only, with great labour, sign his name or spell out a few sentences.

The answer to the puzzle is that the Gothic Freemasons who built the cathedrals, priories, abbeys, etc., practiced an art which of itself required an education; so education was an integral part of their life and work. To be such a Freemason was to be an educated man. Thus the connection between Freemasonry and the Arts and Sciences was not an artificial one, but a necessary one. In a period without schools, an education could not be called schooling, college or university; it was called the Liberal Arts and Sciences. After the system of Speculative Freemasonry was established in the Eighteenth Century the emphasis on education was not only retained but was magnified, and it was called by its old name. The two pillars were retained; a prominent place was given to the Arts and Sciences in both the Esoteric (*obscure*) and the Exoteric (*capable of being understood by all*) portions of the Second Degree. Twentieth Century Freemasons feel as by a kind of instinct that education inevitably and naturally is one of their concerns; they take the motto, *"Let there be light,"* with seriousness and earnestness.

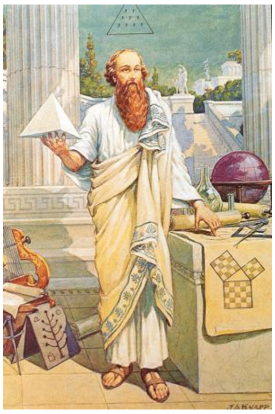
This is a striking fact; that there is a continuous emphasis on education by the same Fraternity through eight or nine centuries of time. The memory of that long tradition, the sense of continuing now what has been practiced for so long, is alive in the Masonic consciousness today. Masons have seen education persist through social, religious, political revolutions, from one language to another, from one country to another; they are therefore indifferent to the labels by which education is named else they would substitute *"education"* for *"Liberal Arts and Sciences",* and they are likely to believe, as against academic experimentalists and innovators, that the imperishable identity and long-continued practice of education means that, at the least, there is one curriculum, not countless possible curricula; and that it universally consists of the language, as it is written or spoken and is its structure, of mathematics, of history, of science, and of literature; an apprentice in life must begin with these; what else he learns in addition is determined by what art, trade, or vocation he is to enter. The fact that education belongs essentially to the nature of Freemasonry and ever has, possesses a critical importance for the history of the Craft; and is one of the facts by which the central problem of that history can be solved.

There were hundreds of craft guilds, fraternities, societies and skilled trades in the Middle Ages; a few of them were larger, more powerful, and far more wealthy than the Mason's Craft, and they also had legends, traditions, officers, rules and regulations, possessed charters, took oaths, had ceremonies, admitted *"non-operatives"* to membership. Why then did Freemasonry stand aside and apart from the others? Why did it alone survive the others? Why did not the others, like Freemasonry, long after the Middle Ages had passed, flower into world-wide fraternities? What unique secret did Freemasonry possess that they did not? It is because Freemasonry had, in itself, and from the beginning, so much for the mind to ponder on; so much of the arts and sciences to think about; so its members were compelled to think and to learn as well as to use tools. It possessed what no other Craft possessed, and which can be described by no better name than philosophy, though it is a misnomer, for the Freemasons were not theorizers but found out a whole set of truths in the process of their work; and these truths were not discovered or even guessed at by church, state, or the populace for many years to come.

When after 1717 the Lodges were thrown open to men of every walk and vocation, these latter people discovered, in the ancient Craft, such a wealth of thought and learning, as must ever be, inexhaustible, and they have since written some tens of thousands of books about it, and have expounded upon it among themselves in tens of thousands of speeches and lectures. Furthermore they found that from the beginning of Masonry, education had never been considered by Freemasonry to be abstract, academic, or detached, a luxury for the few, a privilege for the rich, a necessity only for one or two professions, a monopoly of the learned, and something in books. They found that education belonged to work; this connecting of education with work, this insistence that work involves education, was not dreamed of in Greece and Rome, was not seen in the Middle Ages, and would have aroused a sense of horror if it had been, and even in modern times is only beginning to be seen. The uniqueness of this discovery explains in part the uniqueness of Freemasonry then and thereafter.

Source: Mackey's Encyclopaedia of Freemasonry.

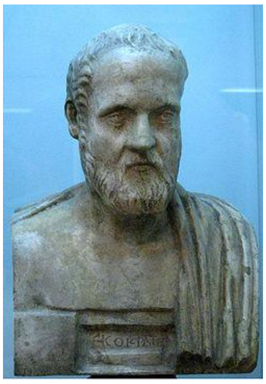
From this we can deduce that like much of Freemasonry, the liberal arts and sciences in the Middle Ages were believed to be the sum total of all knowledge that was worthwhile to a complete education. They were known as *"artes liberales"* from the Latin *"liber"* meaning Free. In this sense they were the subjects available to free men whereas the *"artes illiberales"*, were taught for purely economic reasons so that a man may earn a living. These arts were the operative arts of the workmen and were considered less desirable educational pursuits.



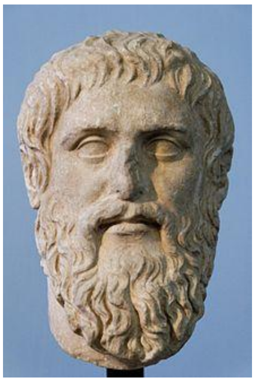
While we have adopted the seven liberal arts and sciences from the Medieval era, they were known in the time of Pythagoras and Plato. The inclusion of grammar, rhetoric and logic in the ancient curriculum was mainly due to the work of Isocrates, who had founded his academy in Athens in 393 BC, six years before Plato founded his, which uniquely for the time, was open to both men and women.

Pythagoras

Isocrates was an ancient Athenian orator, *or rhetorician* **[2] [ret-o-rish'an]**, and teacher whose writings are an important historical source on the intellectual and political life of Athens of his day, The school he founded differed markedly in its aims from the Academy of Plato and numbered among its pupils men of eminence from all over the Greek world. *(Not to be confused with Socrates.)*



Isocrates



Plato and Isocrates together shaped the course of education for millennia. In Roman times the study of Rhetoric and Grammar continued, and in the Middle Ages, while education became Christianised, the subjects remained.

Plato.

The Liberal Arts, as reconnected to their origins, still today, do the same as in the past. The *Trivium* is the rediscovery of the essential being of every man the *Quadrivium* is essentially the search for abstract truth.

Now we have to ask the question; why Three + Four Arts?

The first three arts, Grammar, Rhetoric and Logic form the *"three ancient arts of discourse"*, or *Trivium*,**[3]** Latin for *"Three Ways"* or *"Three Roads"*. Later in medieval times the study of logic, grammar and rhetoric was considered a prerequisite for the *Quadrivium* **[3]** (*Latin for "Four Ways" or "Four Roads"*), which was made up of arithmetic, geometry, music, and astronomy. The *Trivium* was the beginning of the Liberal Arts, and at many medieval universities this would have been the principal undergraduate course. The *Quadrivium* would complete the student's formal education. An interesting observation: The contrast between the simpler *Trivium* and more difficult *Quadrivium* gave rise to the word "trivial". The *Trivium* does not address any specific subject, instead it teaches the student to read and write, debate, compare, analyse and make conclusions about subjects. The teaching of the *Quadrivium* assumes that the *Trivium* has been fully mastered - now the student is properly prepared to explore other sciences.

[2] A Rhetorician is a skilled speaker or writer sometimes considered a speaker or writer of elaborate or fine-sounding but insincere language. *Encarta Dictionary.*
[3] ***Trivium*** has the same root derivation as in Triplets and ***Quadrivium*** has the same root derivation as Quadruplets.

Considering the rise in complexity from basic grammar to measuring the motion of planets, it is natural to conclude that the learning process must follow: Or*, "3 simple arts that enable you to master 4 complex sciences",* or still *"3 arts to express, communicate and compare, which shall serve you as tools, plus 4 sciences that shall open the universe to be measured and understood."*

At many medieval universities, the *Quadrivium* would have been the course leading to the degree of Master of Arts, after the Bachelor of Arts had been obtained. To ignore this order would be the same as teaching advanced calculus before the student is familiar with basic arithmetic or knows how to read. This is the only way the student would receive formal education in ancient and medieval times, and this system has reflections echoed in our modern education system today. Once the seven arts and sciences were mastered, he would have completed his education path and would be a full or free man, able to better understand God's creation and its mysteries.

From ancient Greece to the late 19th Century, the *Trivium* was a fundamental path of education, used to train public speakers and writers to direct audiences to action with their arguments. Philosophers, lawyers, public servants, leaders, military officers and teachers relied on the mastery of the *Trivium* to perform their duties and influence people, the knowledge of discourse and persuasion as we have already discovered came originally from the schools of Aristotle, Plato and Socrates in ancient Greece. It also worthy to note that some researchers believe that the Greek philosophers derived their knowledge from Egyptian masters.

Sanctius, an Ancient Greek writer who wrote a Theory of Language, wrote: *"God created man, to be the participant of reason and as he willed him to be a social being, he bestowed upon him the gift of language, in the perfecting of which there are three aids. The first is Grammar which rejects from language all solecisms (grammatical mistakes) and barbarous expressions; the second is Logic which is occupied with the truthfulness of language; and the third is Rhetoric which seeks only the adornment of language."*

So the seven liberal arts and sciences were broken into two groups. One concerning *language* and the other concerning *mathematics***.** Grammar is the mechanics of a language; rhetoric is the use of language to instruct and persuade; logic is the *"mechanics"* of thinking clearly, of comparison and analysis.

Sister Miriam Joseph, PhD (1898-1982), a member of the Sisters of the Holy Cross and an author specialized in medieval education, described them as: *grammar*, the art of inventing symbols and combining them to express thought; *Logic* is the art of thinking; and *rhetoric*, the art of communicating thought from one mind to another, the adaptation of language to circumstance.

Grammar.

Let us start with some very powerful quotes:

"Grammar matters not only for how it transfers power but for its intrinsic beauty and revelatory qualities."
Mary Ehrenworth and Vicki Vinton, The Power of Grammar: Unconventional Approaches to the Conventions of Language. (Heinemann, 2005).

"What I know about grammar is its infinite power. To shift the structure of a sentence alters the meaning of that sentence." *American essayist and novelist Joan Didion, quoted by Donald Murray in Writing to Deadline: The Journalist at Work (Heinemann, 2000).*

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"Grammar which rejects from language all solecisms (grammatical mistakes) and barbarous expressions".
Sanctius, an Ancient Greek writer who wrote a Theory of Language.

Why Does Grammar Matter?

Grammar is important because it is the language that makes it possible for us to talk about language. Grammar names the types of words and word groups that make up sentences not only in English but in any language. As human beings, we can put sentences together even as children, we can all *do* grammar. But to be able to talk about how sentences are built, about the types of words and word groups that make up sentences, that is *knowing about* grammar. And *knowing about* grammar offers a window into the human mind and into our amazingly complex mental capacity. People associate grammar with errors and correctness. But *knowing about* grammar also helps us understand what makes sentences and paragraphs clear and interesting and precise. Grammar is the structural foundation of our ability to express ourselves. The more we are aware of how it works, the more we can monitor the meaning and effectiveness of the way we and others use language. It can help foster precision, detect ambiguity, and exploit the richness of expression available in English. And it can help everyone.

"It is necessary to know grammar, and it is better to write grammatically than not, but it is well to remember that grammar is common speech formulated. Usage is the only test."
William Somerset Maugham, The Summing Up, 1938

Hear the word *glamour* and what comes to mind?

Celebrities, most likely; limousines and red carpets, swarms of paparazzi and more money than sense. But, odd as it may sound, *glamour* comes directly from a decidedly less glamorous word, *grammar*. During the Middle Ages, *grammar* was often used to describe learning in general, including the magical, occult practices popularly associated with the scholars of the day. People in Scotland pronounced *grammar* as "glam-our," and extended the association to mean magical beauty or enchantment. In the 19th century, the two versions of the word went their separate ways, so that our study of English grammar today may not be *quite* as glamorous as it used to be.

But the question remains: what *is* grammar?

There are two definitions:

The first: **Descriptive grammar** refers to the structure of a language as it's actually used by speakers and writers.

The second: **Prescriptive grammar** refers to the structure of a language as certain people think it *should* be used.

Both kinds of grammar are concerned with rules, but in different ways. Specialists in descriptive grammar, called *linguists*, study the rules or patterns that underlie our use of words, phrases, clauses, and sentences. On the other hand, prescriptive grammarians, such as most editors and teachers, lay out rules about what they believe to be the “correct” or “incorrect” use of language. There is also a misconception, held by many, that grammar only refers to the written language, but it is just important in the spoken word.

What is the value of studying grammar?

The study of grammar all by itself won't necessarily make you a better writer or speaker. But by gaining a clearer understanding of how our language works, you should also gain greater control over the way you shape words into sentences and sentences into paragraphs. In short, studying grammar may help you become a more *effective* writer or speaker. Descriptive grammarians generally advise us not to be overly concerned with matters of *correctness*: language, they say, isn't good or bad; it simply *is*. As the history of the glamorous word *grammar* demonstrates, the English language is a living system of communication, a continually evolving affair. Within a generation or two, words and phrases come into fashion and fall out again. Over centuries, word endings and entire sentence structures can change or disappear. To demonstrate this let me refer you to one of my favourite authors, Sir Arthur Conan Doyle, the master mind behind "Sherlock Holmes". Conan Doyle was a master of language but a language form that has since changed dramatically. I love his novels not only for the mysteries but also for the beauty of the language and the way he describes so vividly a scene.

"The journey was a swift and pleasant one, in a very few hours the brown earth had become ruddy, the brick had changed to granite, and red cows grazed in well-hedges fields where the lush grasses and more luxuriant vegetation spoke of a richer if not of a damper climate."

Prescriptive grammarians prefer giving practical advice about using language: straightforward rules to help us avoid making errors. The rules may be over-simplified at times, but they are meant to keep us out of trouble, the kind of trouble that may distract or even confuse our readers or listeners.

Language is the human ability to acquire and use complex systems of communication, and a language is any specific example of such a system. The scientific study of language is called linguistics. Used as a general concept, "language" may refer to the cognitive ability to learn and use systems of complex communication, or to describe the set of rules that makes up these systems, or the set of utterances that can be produced from those rules. Human language relies entirely on social convention and learning. Its complex structure affords a much wider range of expressions than any known system of animal communication. Language is thought to have originated when the early primates started gradually changing their primitive communication systems, acquiring the ability to form a theory of other minds and a shared intentionality, and many linguists see the structures of language as having evolved to serve specific communicative and social functions. Humans acquire language through social interaction in early childhood, and children generally speak fluently when they are approximately three years old. The use of language is deeply entrenched in human culture.

The New Webster Encyclopaedic Dictionary contains the following meaning:

Grammar: noun [Fr. *gramaire*, from Gr. *gramma*, a letter, *graphō*, to write]. The exposition of the principles which underlie the use of language; a system of general principles and of particular rules for speaking or writing a language. Language as regulated by rules or usage; propriety of speech.

Grammar is the first subject of the Trivium as it is the very foundation of our language or means of communication and is that portion of language that allows us to fine tune our speech like the ashlars and remove all barbarous expressions. It defines the rules used to construct phrases, sentences, words, and connects these elements to communicate ideas in a given language. An understanding of this first art is necessary for all others to be learned.

As Napoleon Bonaparte said, *“By our words we rule the world”*.

Many people who write about grammar seem to think that grammar means *"any sort of rule of language, especially writing"*.

In linguistics, grammar is the set of structural rules that governs the composition of clauses, phrases, and words in any given natural language. The term refers also to the study of such rules, and this field includes **morphology**, which is the structure of words, **syntax**, the organisation of words in a sentence, and **phonology**, the study of the sounds of speech, often complemented by **phonetics**, the sound system of language, **semantics**, the study of the meaning in language, and **pragmatics**, the study of the use of language.

Linguists do not normally use the term 'grammar' to refer to spelling rules, although usage books and style guides that call themselves grammars may also refer to spelling and punctuation. The term *grammar* is often used by non-linguists with a very broad meaning. As Jeremy Butterfield puts it, *"Grammar is often a generic way of referring to any aspect of English that people object to."* However, linguists use it in a much more specific sense. Speakers of a language have in their heads a set of rules for using that language. This is a grammar, and the vast majority of the information in it is acquired, at least in the case of one's native language, not by conscious study or instruction, but by observing other speakers; as we have previously stated, much of this work is done during infancy. Learning a language later in life usually involves a greater degree of explicit instruction. Linguistic researchers have found that children instinctively learn language irrespective of how complicated it is. They learn how to form words and relate them to people, objects or actions. But what is even more intriguing is that they instinctively learn the rules of grammar. They learn sentences in order to communicate but as their vocabulary broadens they put their own sentences together, replacing nouns with other nouns, verbs with other verbs, adjectives with other adjectives and so on. Researchers have also found that they just don't mimic their parents or adults but actually become creative with the language at a very early age because they understand the basic rules of grammar. If you asked a child *"what is a noun?"* they could not answer that question; however, it would be unlikely to hear a child use a noun in place of a verb or vice versa.

The first systematic grammars originated in Iron Age India, with Yaska (6th century BC), Pāṇini (4th century BC) and his commentators Pingala (c. 200 BC), Katyayana, and Patanjali (2nd century BC). In the West, grammar emerged as a discipline in Hellenism from the 3rd century BC forward with authors like Rhyanus and Aristarchus of Samothrace, the oldest existing work being the *Art of Grammar* (Τέχνη Γραμματική), attributed to Dionysius Thrax (c. 100 BC). Latin grammar developed by following Greek models from the 1st century BC, due to the work of authors such as Orbilius Pupillus, Remmius Palaemon, Marcus Valerius Probus, Verrius Flaccus, and Aemilius Asper.

One of the strengths of Freemasonry is the Ritual that has been developed over centuries of writing. It epitomises the correct use of language and grammar, so if we want to improve; then our continued study of the ritual will give us great insight into the subject of grammar. Do we just hear the words of the charges or do we consider the significance of the words and their meaning? Does our everyday language benefit from the beautiful prose that it contains? Do we strive to express ourselves in a way that we so admire in others? So much of the ritual we learn is the expression of years of learning we can but learn from it. Once a student learns how to read and write properly, he is now prepared to manipulate words and sentences to express complex ideas. Mastering Rhetoric is an intermediate step before delving into the more complex domain of Logic.

Why should we have an interest in grammar?

The answer is simple, without grammar, what has been written here and read so far would be totally unintelligible. It would be just a string of words without form or meaning. One of the highly prized tenants of the craft is to make good men better. The study and appreciation of grammar will enable us to achieve and promote the object of grammar: to expound the principles which underlie the use of language, to fine tune our speech and remove all barbarous and unbecoming expressions. Become more expert in the creation of our own language so that our communication with others becomes more meaningful.

Rhetoric.

Rhetoric is the study of effective speaking and writing, and the art of persuasion.

In its long and vigorous history rhetoric it has enjoyed many definitions, accommodated differing purposes, and varied widely in what it included. And yet, for most of its history it has maintained its fundamental character as a discipline for training students, to perceive how language is at work orally and in writing, and to become proficient in applying the resources of language in their own speaking and writing. Discerning how language is working in others' or one's own writing and speaking, one must, artificially, divide form and content, *what* is being said and *how* this is said. Because rhetoric examines so attentively the *how* of language, the *methods* and *means* of communication, it has sometimes been discounted as something, only concerned with style or appearances, and not with the quality or *content* of communication. Traditionally, the point of studying rhetoric has been to develop the capacity to produce appropriate and effective language in any situation.

To quote from the writings of Aristotle: *"Rhetoric is concerned with such things that come within the general knowledge of all men and belong to no definite science. Accordingly all men make use of it; for, to a certain extent, all men attempt to discuss statements and to maintain them, to defend themselves and question others. Ordinary people do this either at random or through practice and from acquired habit. Both ways being possible, for it is possible to ask the reason why some speakers succeed through practice and other spontaneously. Everyone will agree that such an inquiry is the function of an art."*

The Three Branches of Classical Rhetoric:

Deliberative (legislative, to exhort or dissuade)

Judicial (forensic, to accuse or defend)

Epideictic [epi-dec-tic] (ceremonial, to commemorate or blame)

The Five Canons or Offices of Classical Rhetoric:

Invention.

Arrangement.

Style.

Memory.

Delivery.

And we will discuss these in detail later in the paper.

"What has changed is that, where for hundreds of years rhetoric was at the centre of Western education, it has now all but vanished as an area of study; divided up between linguistics, psychology, and literary criticism."
(Sam Leith, Words Like Loaded Pistols: Rhetoric From Aristotle to Obama. Basic Books, 2012)

Broadly defined in our own time as the art of effective communication, the *rhetoric* studied in ancient Greece and Rome, from roughly the fifth century B.C. to the early Middle Ages, was primarily intended to help citizens plead their claims in court. Though the early teachers of rhetoric, known as Sophists, were criticized by Plato and other philosophers, the study of rhetoric soon became the cornerstone of classical education. Modern theories of oral and written communication remain heavily influenced by the basic rhetorical principles introduced in ancient Greece by Isocrates and Aristotle, and in Rome by Cicero and Quintilian.

"The word rhetoric *can be traced back ultimately to the simple assertion "I say" (eiro in Greek). Almost anything related to the act of saying something to someone, in speech or in writing, can conceivably fall within the domain of rhetoric as a field of study".*

(Richard E. Young, Alton L. Becker, and Kenneth L. Pike, Rhetoric: Discovery and Change, *1970)*

A long, unanswered question for students and philosophers alike has been: why study rhetoric? The works of the classical rhetorician **[ret-o-rish'an],** Aristotle, suggests that, *"we must be able to employ persuasion…in order that we may see clearly what the facts are, and…if another man argues unfairly, we on our part may be able to confute him",* meaning that there is a need to study rhetoric simply for personal benefit and means of persuasion.

The first thing that must be known about rhetoric is that it surrounds each community in advertisements, conversations, art, movies, music and body language. Rhetoric is employed in each avenue, regardless of whether or not the user is conscious of his or her use of rhetoric. Studying rhetoric allows one to become conscious of the workings of rhetoric and how it can be skilfully applied to transform speaking and writing and thereby make us more successful and skilful communicators and more astute and perceptive audiences.

Rhetoric was taught in universities during the Middle Ages as one of the three original liberal arts or trivium, along with logic and grammar. During the medieval period, political rhetoric declined as republican oratory died out and the emperors of Rome gained increasing authority. With the rise of European monarchs in following centuries, rhetoric shifted into the courtly and religious areas. Poetry and letter writing, for instance, became a central component of rhetorical study during the Middle Ages. Rhetorical education became more restrained as style and substance separated in 16th-century France and attention turned to the scientific method.

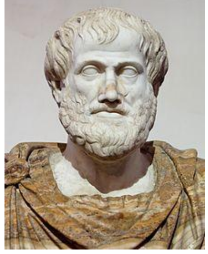
In the 18th century, rhetoric assumed a more social role, initiating the creation of new education systems. "Elocution Schools" arose, predominantly in England, in which they analysed classic literature, most notably the works of William Shakespeare, and discussed pronunciation tactics. The study of rhetoric underwent revival with the rise of democratic institutions during the late 18th and early 19th centuries. Scotland's author and theorist **Hugh Blair** [1] served as a key leader of this movement during the late 18th century. In his most famous work "Lectures on Rhetoric and Belles Lettres", he advocates rhetorical study for common citizens as a resource for social success.

Throughout the 20th century, rhetoric developed as a concentrated field of study with the establishment of rhetorical courses in high schools and universities. Courses such as public speaking and speech analysis use fundamental Greek theories; such as the modes of persuasion: ethos, pathos, and logos, as well as trace rhetorical development throughout the course of history. Rhetoric has earned a more esteemed reputation as a field of study with the emergence of Communication Studies departments in university programs and in conjunction with linguistics. Rhetorical study has broadened in scope, and is especially utilized by the fields of marketing, politics, and literature.

The New Webster Encyclopaedic Dictionary contains the following definition:

rhetoric: noun [Fr. *rhétorique*, L. *rhetorica*, from Gr. *hē rhētorikē* (*technē*, art, understood), from *rhētōr*, a public speaker, from *rheō*, to speak.] The art or branch of knowledge which treats of the rules or principles underlying all effective composition whether in prose or verse; the art which teaches oratory; the rules that govern the art of speaking with propriety, elegance, and force.

Rhetoric is the art, which allows us to persuade and have an effect upon the listener. It is also the art of effective or persuasive speaking or writing, especially the exploitation of figures of speech and other compositional techniques. It is the art of discourse that aims to improve the capability of writers or speakers that attempt to inform, persuade or motivate particular audiences in specific situations.



Its best known definition comes from Aristotle who considers it a counterpart of both logic and politics, and calls it *"the faculty of observing in any given case the available means of persuasion."*

Aristotle

[1] Hugh Blair FRSE was a Scottish minister of religion, author and rhetorician, considered one of the first great theorists of written discourse. As a minister of the Church of Scotland, and occupant of the Chair of Rhetoric and Belles Lettres at the University of Edinburgh, Blair's teachings had a great impact in both the spiritual and the secular realms. Best known for Sermons, a five volume endorsement of practical Christian morality, and Lectures on Rhetoric and Belles Lettres, a prescriptive guide on composition, Blair was a valuable part of the Scottish Enlightenment.

Let us now look at it from a Masonic perspective.

Mackey's Encyclopaedia of Freemasonry gives the following explanation of rhetoric.

Rhetoric: The art of embellishing language with the ornaments of construction, so as to enable the speaker to persuade or affect his hearers. It supposes and requires a proper acquaintance with the rest of the liberal arts; for the first step towards adorning a discourse is for the speaker to become thoroughly acquainted with his subject, and hence the ancient rule that the orator should be thoroughly acquainted with all the arts and sciences. Its importance as a branch of the liberal education is recommended to the Mason in the Fellow Craft's degree. It is one of the seven liberal arts and sciences, the second in order, and is described in the ancient Constitutions as *"retoricke that teacheth a man to speake fine and in subtle terms."* -*Harliean Manuscripts.*

Rhetorics typically provide *heuristics*, **[yoo-ris-tiks]** or a way of solving problems based on experience so as to gain understanding, discovering, and developing arguments for particular situations, such as Aristotle's three persuasive audience appeals, logos, or reasoned discourse, pathos, or tragedy and ethos shared fundamental traits.

Let us examine how to use each of these to obtain rhetorical proof:

ethos: Aristotle's theory of character and how the character and credibility of a speaker can influence an audience to consider him/her to be believable. This could be any position in which the speaker, whether an acknowledged expert on the subject, or an acquaintance of a person who experienced the matter in question, knows about the topic. For instance, when a magazine claims that *An MIT professor predicts that the robotic era is coming in 2050,* the use of big-name "MIT", a world-renowned American university for the advanced research in mathematics, science, and technology, establishes the "strong" credibility.

There are three qualities that contribute to a credible ethos and they include perceived intelligence, virtuous character, and goodwill. An audience is more likely to be persuaded by a credible source because they are more reliable.

pathos: the use of emotional appeals to alter the audience's judgment. This can be done through metaphor, amplification, storytelling, or presenting the topic in a way that evokes strong emotions in the audience. Aristotle used pathos as a corrective measure to help the speaker create appeals to emotion to motivate decision making. George Kennedy claims that pathos was an early discussion of human psychology. Strong emotions are likely to persuade when there is a connection with the audience.

logos: the use of reasoning, either inductive or deductive, to construct an argument. Logos appeals include appeals to statistics, mathematics, logic, and objectivity. For instance, when advertisements claim that their product is: *37% more effective than the competition,* they are making a logical appeal.

Inductive reasoning uses examples such as historical, mythical, or hypothetical to draw conclusions.

Deductive reasoning, or "enthymematic"**[enthe-mematic]** reasoning, uses generally accepted propositions to derive specific conclusions. The term *logic* evolved from *logos*. Aristotle emphasized enthymematic reasoning as central to the process of rhetorical invention, though later rhetorical theorists placed much less emphasis on it.

An *"enthymeme"* **[1] [enthe-meem]** would follow today's form of a syllogism; however it would exclude either the major or minor premise. An enthymeme is persuasive because the audience is providing the missing premise. Because the audience is able to provide the missing premise, they are more likely to be persuaded by the message.

Aristotle also identifies three different types or genres of civic rhetoric: **Forensic** also known as **Judicial**, was concerned with determining truth or falsity of events that took place in the past, such as, issues of guilt. An example of forensic rhetoric would be in a courtroom, **Deliberative** also known as **Political**, was concerned with determining whether or not particular actions should or should not be taken in the future.

Making laws would be an example of deliberative rhetoric, and **Epideictic** also known as **Ceremonial**, was concerned with praise and blame, values, right and wrong, demonstrating beauty and skill in the present. Examples of epideictic rhetoric would include a eulogy or a wedding toast.

[1] An enthymeme is an argument in which one proposition is suppressed - i.e. it's missing for one reason or another.

In ancient times Plato defined rhetoric as: *the persuasion of ignorant masses within the courts and assemblies*. In his opinion it was merely a form of flattery.

Isocrates however takes a different attitude and states: *"We have come together and founded cities and made laws and invented arts; and generally speaking, there is no institution devised by man which the power of speech has not helped us to establish."*

With this statement he argues that rhetoric is a fundamental part of civic life in every society and that it has been necessary in the foundations of all aspects of society.

The Five Canons of Rhetoric serve as a guide to creating persuasive messages and arguments:

Invention - the process of developing and refinement of an argument.

Style - determining how to present the arguments**.**

Arrangement - organizing the arguments for extreme effect usually beginning with the *exordium* **[ex-or-di-um]** or opening statement.

Delivery - the gestures, pronunciation, tone and pace used when presenting the persuasive arguments.

Memory - the process of learning and memorizing the speech and persuasive messages. (This was the last canon of rhetoric that was added much later to the original four canons.)

From Ancient Greece to the late 19th century, it was a central part of Western education, filling the need to train public speakers and writers to move audiences to action with arguments. Today rhetoric is treated as human communication that includes purposeful and strategic manipulation of symbols. Public relations, lobbying, law, marketing, professional and technical writing, and advertising are modern professions that employ rhetorical practitioners. Individuals engage in the rhetorical process anytime they speak or produce meaning. In the field of science, which was once viewed as being merely the objective testing and reporting of knowledge, scientists must now persuade their audiences to accept their findings by sufficiently demonstrating that their study or experiment was conducted reliably and resulted in sufficient evidence to support their conclusions. Rhetoric has changed in its form over the years and has been reproduced in *'elocution'* and more recently in debating clubs and public speaking forums.

Rhetoric has its origins in Mesopotamia. Some of the earliest examples of rhetoric can be found in the Akkadian **[a'keidian]** writings of the princess and priestess **Enheduanna** **[2] [En-hedu-ana]** (ca. 2285-2250 BC), while later examples can be found in the Neo-Assyrian Empire during the time of Sennacherib **[se'nae-karib]** (704–681 BC). In ancient Egypt, rhetoric has existed since at least the Middle Kingdom period (ca. 2080-1640 BC). The Egyptians held eloquent speaking in high esteem, and it was a skill that had a very high value in their society. The *"Egyptian rules of rhetoric"* also clearly specified that *"knowing when not to speak is essential, and very respected, rhetorical knowledge."* Their *"approach to rhetoric"* was thus a *"balance between eloquence and wise silence."* Their rules of speech also strongly emphasized *"adherence to social behaviours that support a conservative status quo"* and they held that *"skilled speech should support, not question, society."* In ancient China, rhetoric dates back to the Chinese philosopher, Confucius (551-479), and continued with later followers. The tradition of Confucianism emphasized the use of eloquence in speaking. The use of rhetoric can also be found in the ancient Biblical tradition.

Confucius

[2] Enheduanna also transliterated as **En-hedu-ana** or **EnHeduAnna** ("en" means high priest or high priestess, and "hedu" means adornment, so this name translates to "high priestess adornment of the god, An"),she was an Akkadian princess as well as High Priestess of the Moon god Nanna in the Sumerian city-state of Ur. She was the first known holder of the title "En Priestess", a role of great political importance that was often held by royal daughters. Enheduanna was an aunt of Akkadian king Narām-Sîn and was one of the earliest women in history whose name is known.

Regarded by literary and historical scholars as possibly the earliest known author and poet, Enheduanna served as the "High Priestess" during the third millennium BCE. She was appointed to the role by her father, King Sargon of Akkad. Her mother was Queen Tashlultum. Enheduanna has left behind a body of literary works, definitively ascribed to her, that include several personal devotions to the goddess Inanna and a collection of hymns known as the "Sumerian Temple Hymns," regarded as one of the first attempts at a systematic theology.

In ancient Greece, the earliest mention of oratorical skill occurs in Homer's *Iliad*, where heroes like Achilles, Hektor, and Odysseus were honoured for their ability to advise and exhort their peers and followers, the Laos or army, in wise and appropriate action. With the rise of the democratic polis, speaking skill was adapted to the needs of the public and political life of cities in ancient Greece, much of which revolved around the use of oratory as the medium through which political and judicial decisions were made, and through which philosophical ideas were developed and disseminated. For modern students today, it can be difficult to remember that the wide use and availability of written texts is a phenomenon that was just coming into vogue in Classical Greece. In Classical times, many of the great thinkers and political leaders performed their works before an audience, usually in the context of a competition or contest for fame, political influence, and cultural capital; in fact, many of them are known only through the texts that their students, followers, or detractors wrote down.

As has already been noted*, rhetor* **[ree-ter]** was the Greek term for orator: A *rhetor* was a citizen who regularly addressed juries and political assemblies and who was thus understood to have gained some knowledge about public speaking in the process, though in general language was often referred to as *logôn techne, "skill with arguments"* or *"verbal artistry."*

Why rhetoric?

We all admire the person who can speak with conviction and authority. The person who, it is a pleasure to listen to, a person whose oratory skill we aspire to imitate. Some people believe that to make an impression we have to be verbose or long winded, yet we find the most famous quotes we know are short, to the point and very profound. A greater knowledge of the art of rhetoric will enable us to make a greater contribution to public life. It will help us to be more observant of both ourselves and others and assist in achieving greater outcomes in our interpersonal relationships. It will increase our powers of reasoning and aid us in our ability to influence others, make us more inventive in our speech, develop our style in communication, help us to organise objectively what we want to say and play a greater role in how we present ourselves to others.

"Everything has its beauty but not everyone sees it". *Confucius*

Logic.

The last and perhaps most important part of the Trivium is **Logic**, which permits us the gift of reasoning. In a purely Masonic sense it allows us to understand our duties to God and towards each other.

When I was young I thought of logic as an orderly process of solving a problem or defending an argument. To me, logical thoughts and arguments seemed to be the natural order of things but in studying logic as part of the philosophy subject at University I soon found that the study and teachings of logic by the great Greek philosophers was far deeper, more involved and far more complex than I ever imagined. I, therefore do not claim to be an expert in logic but a mere, very interested novice, who truly believes that logic would be the most difficult of the seven Liberal Arts and Sciences.

The following is therefore what I have gleaned from a very thorough research of the subject.

The first question we should ask is:

What Is Logic?

In elementary school, you studied such things as reading, writing, and arithmetic. These subjects are correctly regarded as basic to all further education: One cannot study history, botany, or computers without being able to read. Reading, writing, and arithmetic are the basics, the tools that permit one to study further, and also to drive, to shop, and to get a job. But could there be something more basic than the three basics? Something so obvious that most people do not see it, let alone study it? What is there in common between calculating, reading, and writing? The answer of course is thought. One must think in order to read and write. Thinking, just as everything else, is supposed to follow certain rules, if we are to think correctly. Sometimes we make mistakes in thinking. We jump to conclusions; we make unwarranted assumptions; we generalize. There is a subject that catalogues these mistakes, points them out so that we can recognize them in the future, and then explains the rules for avoiding mistakes. That subject is logic.

Logic is not psychology. It does not describe what people think about or how they reach conclusions; it describes how they ought to think if they wish to reason correctly. It is more like arithmetic than history, for it explains the rules one must follow in order to reach correct conclusions, just as arithmetic explains the rules one must follow to arrive at correct answers. Logic concerns all thought; it is fundamental to all disciplines, from agriculture to astronautics. The term *"logic"* is used quite a lot, but not always in its technical sense. Logic, strictly speaking, is the science or study of how to evaluate arguments and reasoning. Logic is what allows us to distinguish correct reasoning from poor reasoning. Logic is important because it helps us reason correctly — without correct reasoning, we don't have a viable means for knowing the truth or arriving at sound beliefs.

Logic is not a matter of opinion: when it comes to evaluating arguments, there are specific principles and criteria which should be used. If we use those principles and criteria, then we are using logic; if we aren't using those principles and criteria, then we are not justified in claiming to use logic or be logical. This is important because sometimes people don't realize that, what sounds reasonable, isn't necessarily logical in the strict sense of the word. Our ability to use reasoning is far from perfect, but it is also our most reliable and successful means for developing sound judgments about the world around us. Tools like habit, impulse, and tradition are also used quite often and even with some success, yet not reliably so. In general, our ability to survive depends upon our ability to know what is true, or at least what is more likely to be true than not true. For that, we need to use reason. Reason can be used well or it can be used poorly, and that is where logic comes in. Over the centuries, philosophers have developed systematic and organized criteria for the use of reason and the evaluation of arguments. Those systems are what have become the field of logic within philosophy, some of it is difficult, some of it is not, but it is all relevant for those concerned with clear, coherent, and reliable reasoning.

The Greek philosopher **Aristotle** is generally regarded as the *"father"* of logic. Others before him discussed the nature of arguments and how to evaluate them, but he was the one who first created systematic criteria for doing it. His conception of syllogistic logic remains a cornerstone of the study of logic even today. Others who have played important roles in the development of logic include Peter Abelard, William of Occam, Wilhelm Leibniz, Gottlob Frege, Kurt Goedel, and John Venn.

Logic sounds like an obscure subject for academic philosophers, but the truth of the matter is that logic is applicable anywhere that reasoning and arguments are being used. Whether the actual subject matter is politics, ethics, social policies, raising children, or organizing a book collection, we use reasoning and arguments to arrive at specific conclusions. If we don't apply the criteria of logic to our arguments, we cannot trust that our reasoning is sound. When a person makes an argument for a particular course of action, how can that argument be properly evaluated without an understanding of the principles of logic? When a salesman makes a pitch for a product, arguing that it is superior to the competition, how can we determine whether to trust the claims if we aren't familiar with what distinguishes a good argument from a poor one? There is no area of life where reasoning is completely irrelevant or wasted, to give up on reasoning would mean to give up on thinking itself.
The mere fact that a person studies logic doesn't guarantee that they will reason well, just as a person who studies a medical textbook won't necessarily make a great surgeon. The correct use of logic takes practice, not simply theory.

It is important to keep in mind that while much of logic appears to be concerned solely with the process of reasoning and arguing, it is ultimately the product of that reasoning which is the purpose of logic. Critical analyses of the way an argument is constructed are not offered simply to help improve the thinking process in the abstract, but rather to help improve the products of that thinking process, i.e., our conclusions, beliefs, and ideas.

The New Webster Encyclopaedic Dictionary contains the following definition:

logic*: noun* [Fr,*logique;* Gr. *logikē (technē,* art, understood), from *logos,* reason.] The science of reasoning; the science of the operations of the understanding subservient to the estimation of evidence; the science whose chief end is to ascertain the principles on which all valid reasoning depends, and which may be applied to test the legitimacy of every conclusion that is drawn from premises; the art of or practice of reasoning.

This is the standard Webster Dictionary definition however to show how diverse logic is used and considered the following are extracts from different types of dictionaries.

In a **Science Dictionary** the following is the definition of logic:

The study of the **principles of reasoning**, especially of the structure of the propositions as distinguished from their content and method and validity in deductive reasoning.

The American Heritage® Science Dictionary

In a **Cultural Dictionary**:

The branch of philosophy dealing with the principles of reasoning. Classical logic, as taught in ancient Greece and Rome, **systematized rules for deduction**. The modern scientific and philosophical logic of deduction has become closely allied to mathematics, especially in showing how the foundations of mathematics lie in logic.

The American Heritage® New Dictionary of Cultural Literacy, Third Edition

In a **Computing Dictionary**:

A branch of philosophy and mathematics that deals with the formal principles, methods and criteria of validity of inference, reasoning and knowledge. **Logic is concerned with what is true and how we can know whether something is true. This involves the formalisation of logical arguments and proofs in terms of symbols representing propositions and logical connectives.** The meanings of these logical connectives are expressed by a set of rules which are assumed to be self-evident. **Symbolic logic** uses a meta-language concerned with truth, which may or may not have a corresponding expression in the world of objects called existence. In symbolic logic, arguments and proofs are made in terms of symbols representing propositions and logical connectives. The meanings of these begin with a set of rules or primitives which are assumed to be self-evident. Fortunately, even from vague primitives, functions can be defined with precise meaning. **Boolean logic** deals with the basic operations of truth values: AND, OR, NOT and combinations thereof. Predicate logic extends this with existential quantifiers and universal quantifiers which introduce bound variables ranging over finite sets; the predicate itself takes on only the values true and false. Deduction describes how we may proceed from valid premises to valid conclusions, where these are expressions in predicate logic.

Rudolf Carnap [1] used the phrase "rational reconstruction" to describe the logical analysis of thought. **Thus logic is less concerned with how thought does proceed, which is considered the realm of psychology, and more with how it should proceed to discover truth.** It is the touchstone of the results of thinking, but neither its regulator nor a motive for its practice.

The Free On-line Dictionary of Computing, © Denis Howe

Logic (from the Greek λογική, logos) has two meanings: first, **it describes the use of valid reasoning in some activity;** second, it names the normative **study of reasoning** or a branch thereof. In the latter sense, it features most prominently in the subjects of philosophy, mathematics, and computer science.

The Old Masonic Constitutions define logic to be the art *"that teacheth to discern truth from falsehood."*

Source: Mackey's Encyclopaedia of Freemasonry

To my way of thinking, logic is a measured and orderly progression of thought. But before we examine Logic in detail we need to look at the area of science from which it arises and that area of study is Philosophy.

Philosophy is the study of **general and fundamental problems**, such as those connected with reality, existence, knowledge, values, reason, mind, and language. Philosophy is distinguished from other ways of addressing such problems by its critical, generally systematic approach and its reliance on rational argument. In more casual speech, by extension, "philosophy" can refer to "the most basic beliefs, concepts, and attitudes of an individual or group".

The word *"philosophy"* comes from the Ancient Greek φιλοσοφία *philosophia*, which literally means ***"love of wisdom".*** The introduction of the terms *"philosopher"* and *"philosophy"* has been ascribed to the Greek thinker Pythagoras, so we can see an immediate connection to Freemasonry.

Logic as a part of the study of Philosophy is the study of the principles of **correct reasoning**. Arguments use either **deductive** reasoning or **inductive** reasoning. Deductive reasoning is when, given certain statements, called premises, other statements, called conclusions are unavoidably implied. A common convention for a deductive argument is the syllogism. An argument is termed valid if its conclusion does follow from its premises, whether the premises are true or not, while an argument is sound if its conclusion follows from premises that are true. Propositional logic[2] uses premises that are propositions, which are declarations that are either true or false, while predicate logic uses more complex premises called formulae that contain variables. These can be assigned values or can be quantified as to when they apply with the universal quantifier (always apply) or the existential quantifier (applies at least once). Inductive reasoning makes conclusions or generalizations based on probabilistic reasoning.**[3]**

For example, if *"90% of humans are right-handed"* and *"Joe is human"* then *"Joe is probably right-handed"*. Fields in logic include mathematical logic (formal symbolic logic) and philosophical logic.

[1] Rudolf Carnap (May 18, 1891 – September 14, 1970) was a German-born philosopher who was active in Europe before 1935 and in the United States thereafter. He was a major member of the Vienna Circle and an advocate of logical positivism.

[2] Propositional logic, also known as *sentential logic* and *statement logic*, is the branch of logic that studies ways of joining and/or modifying entire propositions, statements or sentences to form more complicated propositions, statements or sentences, as well as the logical relationships and properties that are derived from these methods of combining or altering statements. *Encyclopaedia of Philosophy.*

[3] Probabilistic logic: The aim of a **probabilistic logic** (also **probability logic** and **probabilistic reasoning**) is to combine the capacity of probability theory to handle uncertainty with the capacity of deductive logic to exploit structure. The result is a richer and more expressive formalism with a broad range of possible application areas. Probabilistic logics attempt to find a natural extension of traditional logic truth tables: the results they define are derived through probabilistic expressions instead. A difficulty with probabilistic logics is that they tend to multiply the computational complexities of their probabilistic and logical components. Other difficulties include the possibility of counter-intuitive results, such as those of Dempster-Shafer theory. The need to deal with a broad variety of contexts and issues has led to many different proposals.

From Wikipedia, the free encyclopaedia.

Logic was studied in several ancient civilizations, including India, China, Persia and Greece. In the West, logic was established as a formal discipline by Aristotle, who gave it a fundamental place in philosophy. Logic was further extended by **Al-Farabi** [4] who categorized it into two separates groups (idea and proof).

Al-Farabi

Later, **Avicenna** [5] revived the study of logic and his aim was to prove the existence of God and His creation of the world scientifically and through reason and logic. Avicenna wrote a number of treatises dealing with Islamic theology. In the East, logic was developed by Buddhists and Jains.[6]

Avencia

Logic is often divided into three parts; **inductive** reasoning, **abductive** reasoning, and **deductive** reasoning.

Inductive reasoning is reaching a conclusion based on observation.

Abductive reasoning is a form of logical inference that goes from observation to a hypothesis that accounts for the reliable data (observation) and seeks to explain relevant evidence.

Deductive reasoning is to consider information carefully to find a solution.

"Upon this first, and in one sense this sole, rule of reason, that in order to learn, and in so desiring not to be satisfied what you already incline to think, there follows one corollary which itself deserves to be inscribed upon every wall of the city of philosophy: Do not block the way of inquiry."

Charles Sanders Peirce. "First Rule of Logic"

The concept of logical form is central to logic, it being held that the validity of an argument is **determined by its logical form, not by its content**. Traditional Aristotelian syllogistic logic and modern symbolic logic are examples of formal logics.

Informal logic is the study of natural language arguments. The study of fallacies or invalid arguments is an especially important branch of informal logic. The dialogues of Plato are good examples of informal logic.

Formal logic is the abstract study of propositions, statements, or assertively used sentences and of deductive arguments. The works of Aristotle contain the earliest known formal study of logic. Modern formal logic follows and expands on Aristotle. In many definitions of logic, logical inference and inference with purely formal content are the same.

Symbolic logic is the method of representing logical expressions through the use of symbols and variables, rather than in ordinary language. This has the benefit of removing the ambiguity that normally accompanies ordinary languages, such as English, and allows easier operation. Symbolic logic is often divided into two branches: propositional logic and predicate logic.

Mathematical logic is an extension of symbolic logic into other areas, in particular to the study of model theory, proof theory, set theory, and recursion theory.

[4] Al-Farabi : Abū Naṣr Muḥammad ibn Muḥammad Fārābī; known in the West as **Alpharabius** was a renowned scientist and philosopher of the Islamic Golden Age. He was also a cosmologist, logician, and musician. Through his commentaries and treatises, Al-Farabi became well known among medieval Muslim intellectuals as "The Second Teacher", that is, the successor to Aristotle, "The First Teacher".

[5] Avicenna, was a Persian polymath, who wrote almost 450 treatises on a wide range of subjects, of which around 240 have survived. In particular, 150 of his surviving treatises concentrate on philosophy and 40 of them concentrate on medicine. His most famous works are *The Book of Healing*, a vast philosophical and scientific encyclopaedia, and *The Canon of Medicine*, which was a standard medical text at many medieval universities. The *Canon of Medicine* was used as a text-book in the universities of Montpellier and Leuven as late as 1650. Ibn Sīnā's *Canon of Medicine* provides a complete system of medicine according to the principles of Galen (and Hippocrates). His corpus also includes writing on philosophy, astronomy, alchemy, geology, psychology, Islamic theology, logic, mathematics, physics, as well as poetry. He is regarded as the most famous and influential polymath (or someone with a wide range of knowledge) of the Islamic Golden Age.

[6] Jainism, traditionally known as Jaina dharma, is an Indian religion that prescribes a path of non-violence towards all living beings.

Logical form. Logic is generally considered **formal** when it analyses and represents the *form* of any valid argument type. The form of an argument is displayed by representing its sentences in the formal grammar and symbolism of a logical language to make its content usable in formal inference. If one considers the notion of form too philosophically loaded, one could say that **formalizing simply means translating English sentences into the language of logic.**

Deductive reasoning concerns what follows necessarily from given premises (if a, then b). However, **inductive reasoning**, the process of **deriving a reliable generalization from observations,** has sometimes been included in the study of logic. Similarly, it is important to **distinguish deductive validity and inductive validity.** An inference is deductively valid if and only if there is no possible situation in which all the premises are true but the conclusion false. An inductive argument can be neither valid nor invalid; its premises give only some degree of probability, but not certainty, to its conclusion.

Retroductive inference is a mode of reasoning that Peirce proposed as operating over and above induction and deduction to *"open up new ground"* in the processes of theorizing. He defines retroduction as a logical inference that allows us to *"render comprehensible"* some observations/events we perceive, by relating these back to a **posited[7]** state of affairs that would help to shed light on the observations. Some authors suggest that this mode of inference can be used within social theorizing to postulate social structures/mechanisms that explain the way that social outcomes arise in social life, and that in turn indicates that these structures or mechanisms are alterable with sufficient social will and envisioning of alternatives.

In other words, this logic is specifically liberating in that it can be used by helping to potentially transform our way of organizing our social existence by our re-examining or exploring the deep structures that generate outcomes and life chances for people.

Among the important properties that logical systems can have are:

Consistency, which means that no theorem of the system contradicts another.

Validity, which means that the system's rules of proof never allow a false inference from true premises. A logical system has the property of soundness when the logical system has the property of validity and uses only premises that prove true or, in the case of axioms or generally accepted truths, are true by definition.

Completeness, of a logical system, which means that if a formula is true, it can be proven, if it is true, it is a theorem of the system.

Soundness, the term soundness has multiple separate meanings, which creates a bit of confusion throughout the literature. Most commonly, soundness refers to logical systems, which means that if some formula can be proven in a system, then it is true in the relevant model/structure (if A is a theorem, it is true). This is the converse of completeness. A distinct, peripheral use of soundness refers to arguments, which means that the premises of a valid argument are true in the actual world.

The motivation for the study of logic in ancient times was clear: it is so that one may learn to distinguish good from bad arguments, and so become more effective in argument and oratory, and perhaps also to become a better person.

Half of the works of Aristotle's **Organon [8]** treat inference as it occurs in an informal setting, side by side with the development of the syllogistic, and in the Aristotelian school, these informal works on logic were seen as complementary to Aristotle's treatment of rhetoric.

This ancient motivation is still alive, although it no longer takes centre stage in the picture of logic; typically dialectical logic forms the heart of a course in critical thinking, a compulsory course at many universities.

Argumentation theory is the study and research of informal logic, fallacies, and critical questions as they relate to every day and practical situations. Specific types of dialogue can be analysed and questioned to reveal premises, conclusions, and fallacies. Argumentation theory is now applied in artificial intelligence and law.

[7] Posited: to say that something is true or that something should be accepted as true.

[8]The ***Organon*** (Greek: Ὄργανον, meaning "instrument, tool, organ") is the standard collection of Aristotle's six works on logic.

Logic and the philosophy of language are closely related. Philosophy of language has to do with the study of how our language engages and interacts with our thinking. Logic has an immediate impact on other areas of study. Studying logic and the relationship between logic and ordinary speech can help a person better structure his own arguments and critique the arguments of others. Many popular arguments are filled with errors because so many people are untrained in logic and unaware of how to formulate an argument correctly.

In the 1950s and 1960s, researchers predicted that when human knowledge could be expressed using logic with mathematical notation, it would be possible to create a machine that reasons, or artificial intelligence. This was more difficult than expected because of the complexity of human reasoning. In logic programming, a program consists of a set of axioms and rules. Logic programming systems such as **Prolog** [9] compute the consequences of the axioms and rules in order to answer a query.

Today, logic is extensively applied in the fields of Artificial Intelligence, and Computer Science, and these fields provide a rich source of problems in formal and informal logic.

Why logic?

Well most people would consider themselves very logical in their approach to most things, however when we study the intricacies and history of logic we see that we can make a vast improvement in how we think and handle ideas and arguments. By embracing the fundamentals of logic it will help us to expand our powers of reasoning, it will give us the power to discover truth more effectively. It should help us to gather information and evidence in a more strategic way, to sift through that evidence and come to a logical conclusion, no matter what the subject may be and most of all, be able to distinguish a good argument from a bad argument. And ponder this for a moment that without the art of logic this paper could not have been possible.

In summation of the Trivium, we ask the obvious question, are the Seven Arts and Sciences still as important to us today as they were to the medieval mason?

It largely depends on how intent and devoted we are in keeping the original tenants and teachings of the craft alive.

* * *

Let us now turn to the second part which was the **"Quadrivium"** or path of four roads and included arithmetic, geometry, music and astronomy and reiterate a statement we made at the beginning of this study " let us consider that when we are looking at these subjects we must remember that we are Speculative Masons not operative. So we must not look at the subjects from a practical or mechanical view point but from a philosophical aspect which will change our comprehension of every subject."

Before I start on Arithmetic and Geometry, I would like to explain that I do not consider myself, in any way a mathematician. What I have tried to do, is research the subjects thoroughly and present what I consider to be the most informative and interesting information. In working on these subjects I have found them extremely interesting, quite challenging and with quite a few surprises. I do come from a family of engineers and people involved in using figures for their profession. My mother worked as a bookkeeper in an accountants office at the age of 18 which was very unusual for that era. On my father's side both his grandfathers were stone masons as was his father. My Father became a Mechanical Engineer, Chief Maintenance Engineer for Rheem Australia in Queensland and his brother was a Senior Partner in a large Engineering Firm, he has two sons both civil engineers, the eldest became the Commissioner for Water Resources in Queensland and the younger son, a Rhodes Scholar and Doctor of Engineering and was appointed Chief Engineer of Queensland Main Roads Department. My Nephew, a Civil Engineer working with Light Rail, my Grand Niece, beginning her career as a Mechanical Engineer in Sydney and my Grandson, studying Naval Architecture and Engineering in Launceston. My Brother and I both entered the Accounting and Computer area, so there is something to say for genes. This may explain why I have been fascinated with the two following subjects.

[9] Prolog is a general purpose logic programming language associated with artificial intelligence and computational linguistics.

Arithmetic.

Arithmetic is the process by which we are able to calculate all weights and measures, but in a speculative and philosophical sense can be best summed up by the following quotation:

"That science which is engaged in considering the properties and powers of numbers, and which, from its manifest necessity in all the operations of weighing, numbering, and measuring, must have had its origin in the remotest ages of the world. In the lecture of the degree of Grand Master Architect, the application of this science to Freemasonry is made to consist in its reminding the Mason that he is to continually to add to his knowledge, never to subtract anything from the character of his neighbour, to multiply his benevolence to his fellow-creatures, and to divide his means with a suffering brother." *From Mackey's Masonic Encyclopaedia.*

Arithmetic or arithmetics (from the Greek word *ἀριθμός, arithmos "number"* from Latin *arithmētica,* is the oldest and most elementary branch of mathematics, used very popularly, for tasks ranging from simple day-to-day counting to advanced science and business calculations. It involves the study of quantity, especially as the result of operations that combine numbers. In common usage, it refers to the simpler properties when using the traditional operations of addition, subtraction, multiplication and division with smaller values of numbers. Professional mathematicians sometimes use the term *(higher) arithmetic* when referring to more advanced results related to number theory, but this should not be confused with elementary arithmetic.

The basic arithmetic operations are addition, subtraction, multiplication and division, although this subject also included more advanced operations, such as manipulations of percentages, square roots, exponentiation [1], and logarithmic functions.

The prehistory of arithmetic is limited to a small number of artefacts which may indicate the conception of addition and subtraction, the best-known being the **Ishango bone**[2] from central Africa, dating from somewhere between 20,000 and 18,000 BC although its interpretation is disputed.

The Ishango Bone.

The most interesting, of a large number of tools discovered in 1960 at Ishango, is a bone tool handle called the Ishango Bone (now located on the 19th floor of the Royal Institute for Natural Sciences of Belgium in Brussels, and can only be seen on special demand). At one end of the Ishango Bone is a piece of quartz for writing, and the bone has a series of notches carved in groups (shown above). It was first thought these notches were some kind of tally marks as found to record counts all over the world. However, the Ishango bone appears to be much more than a simple tally. The markings on rows (a) and (b) each add to 60. Row (b) contains the prime numbers between 10 and 20. Row (a) is quite consistent with a numeration system based on 10, since the notches are grouped as 20 + 1, 20 - 1, 10 + 1, and 10 - 1. Finally, row (c) seems to illustrate for the method of duplication (multiplication by 2) used more recently in Egyptian multiplication.

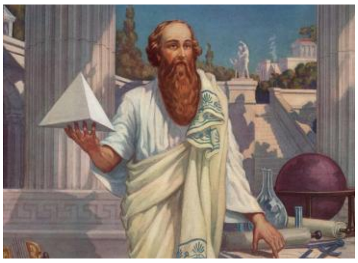
The earliest written records indicate the Egyptians and Babylonians used all the elementary arithmetic operations as early as 2000 BC. These artefacts do not always reveal the specific process used for solving problems, but the characteristics of the particular numeral system strongly influence the complexity of the methods. The hieroglyphic system for Egyptian numerals, like the later Roman numerals, descended from tally marks used for counting. In both cases, this origin resulted in values that used a decimal base but did not include positional notation. Complex calculations with Roman numerals required the assistance of a counting board or the Roman abacus to obtain the results.

[1] The multiplication of a number or quantity by itself a given number of times, the number of times being the power to which the number or quantity is to be raised.

[2] Recent studies with microscopes illustrate more markings and it is now understood the bone is also a lunar phase counter. Who but a woman keeping track of her cycles would need a lunar calendar? Were women our first mathematicians? *from the Department of Mathematics, University of Buffalo.*

Early number systems that included positional notation were not decimal, including the sexagesimals **[sex-a-ges-i-mals]** (base 60) system for Babylonian numerals and the vigesimal**[vi-ges-i-mal]** (base 20) system that defined Maya numerals. Because of this place-value concept, the ability to reuse the same digits for different values contributed to simpler and more efficient methods of calculation. **Positional notation** or **place-value notation** is a method of representing or encoding numbers. Positional notation is distinguished from other notations (such as Roman numerals) for its use of the same symbol for the different orders of magnitude (for example, the "ones place", "tens place", "hundreds place"). This greatly simplified arithmetic leading to the rapid spread of the notation across the world. The continuous historical development of modern arithmetic starts with the Hellenistic civilization of ancient Greece, although it originated later than the Babylonian and Egyptian examples. Prior to the works of Euclid around 300 BC, Greek studies in mathematics overlapped with the philosophical and mystical beliefs.

Greek numerals were used by Archimedes, Diophantus and others in a personal notation not very different from ours. Because the ancient Greeks lacked a symbol for zero (until the Hellenistic period) they used three sets of different symbols. One set for the unit's place, one for ten's place, and one for the hundred's. Then for the thousand's place they would reuse the symbols for the units place and so on. Their addition **algorithm[3]** was identical to ours, and their multiplication algorithm was only very slightly different. Their long division algorithm was the same. The ancient Chinese used a similar positional notation. They also lacked a symbol for zero. Their symbols were based on the ancient counting rods. It is believed the Chinese started calculating with a positional representation around 400 BC. Modern methods for four fundamental operations; addition, subtraction, multiplication, and division, were first devised by Brahmagupta of India. In 650AD the Bishop of Syria wrote: *"Indians possess a method of calculation that no word can praise enough. Their rational system of mathematics, or of their method of calculation. I mean the system using nine symbols."*



We know for certain that Pythagoras established an ethos that changed the course of mathematics. The Brotherhood was effectively a religious community, and one of the idols they worshiped was Number. By understanding the relationships between numbers, they believed that they could uncover the spiritual secrets of the universe and bring themselves closer to the gods. In particular the Brotherhood focused its attention on the study of counting numbers (1,2,3,.....) and fractions. Counting numbers are sometimes called *whole numbers,* and, together with fractions (ratios between whole numbers), they are technically referred to as *rational numbers*.

Among the infinity of numbers, the Brotherhood looked for those with specific significance, and some of those most special were the so-called "perfect" numbers.

According to Pythagoras, numerical perfection depended on a number's divisors (numbers that will divide perfectly into the original one). For instance, the divisors of 12 are 1,2,3,4 and 6. When the sum of a number's divisors is greater than the number itself, it is called an **"excessive"** number. Therefore 12 is an excessive number because the sum of the divisors add up to 16. On the other hand, when the sum of the number's divisors is less than the number itself, it is called **"defective".** So 10 is a defective number because divisors 1,2 and 5 add up to only 8. The most significant and rarest numbers are those whose divisors add up exactly to the number itself, and these are *perfect numbers*, The number 6 has the divisors 1,2 and 3, and consequently it is a perfect number because 1+2+3=6. The next perfect number is 28, the next 496 and the next 8,128.

Euclid.

Euclid discovered that perfect numbers are always the multiple of two numbers, one of which is a power of 2 and the other being the next power of 2 minus 1.

That is to say,

$$6 = 2^1 \text{ x } (2^2 - 1),$$
$$28 = 2^2 \text{ x } (2^3 - 1),$$
$$496 = 24 \text{ x } (2^3 -1).$$

And this was done by men well before the age of computers was even thought of.

Source: Fermat's Enigma by Simon Singh Published by Anchor Books Doubleday.

[3] Algorithm a logical step-by-step procedure for solving a mathematical problem in a finite number of steps, often involving repetition of the same basic operation.

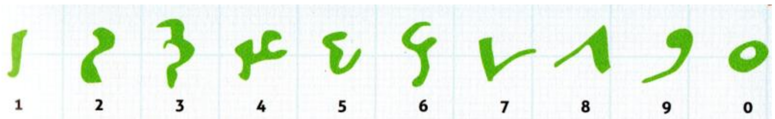
Before we start on the next section I want to explain why I have chosen the Fibonacci numbers to be included in our research. In the first Degree we are encouraged to devote a portion of our leisure hours to the study of such of the Liberal Arts and Sciences as may be within the compass of our attainments and then again in the second Degree we are permitted to extend our researches into the hidden mysteries of nature and science.

As we read on, it will become apparent that the study of the Fibonacci numbers will tick every box, they lay hidden from 1202 to 1611, for four hundred years, also elements of the sequence are found in each of the subjects of the ***Trivium,*** Mathematics, Geometry, Music and Astronomy as well as Nature. I have tried to make this section as easy and as interesting, as it is a very complex subject. I hope you enjoy what I have prepared.

The main source for this section comes from three publications: *"The (Fabulous) Fibonacci Numbers"* by Alfred S. Posamentier & Ingmar Lehmann, *"Awesome Algebra"* by Michael Willers and *"Sacred Geometry"* by Stephen Skinner.

In 1200 AD Leonardo of Pisa or more commonly known as Fibonacci wrote in *Liber Abaci " or "book of calculation." The method of the Indians (Modus Indoram) surpasses any know method to compute. It is a marvellous method. They do their computations using nine figures and symbol zero."*

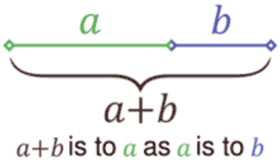
Leonardo of Pisa



The Indian symbols for the numbers zero to 9 with their English equivalent.

He introduced this practical numeration system for calculating algorithms and algebraic methods and a new facility with fractions which was not able with the Roman Numeral system. This was the original decimal system which is used throughout the world today.

The golden ratio, also known as the golden proportion, golden mean, golden section, golden number, and divine proportion is the division of a given unit of length into two parts such that the ratio of the shorter to the longer equals the ratio of the longer part to the whole or, when a line is divided such that the ratio of the longer part of the line to the whole is exactly the same ratio as the shorter part of the line is to the longer part.



It is a number often encountered when taking the ratios of distances in simple geometric figures, such as the pentagon, pentagram, decagon and dodecahedron. It is a ratio or proportion defined by the number Phi = 1.618033988749895... It is an irrational number, meaning it is a number that cannot be written as a simple fraction - the decimal goes on forever without repeating. Phi, like Pi, is a ratio defined by a geometric construction. Just as Pi is the ratio of the circumference of a circle to its diameter, Phi is simply the ratio of the line segments that result when a line is divided in one very special and unique way.

Fibonacci was a serious mathematician, who first learned mathematics in his youth in Bugia, a town on the Barbary Coast of Africa, which had been established by merchants from Pisa. He studied counting so that he could follow in his father's footsteps as a merchant whose main task was converting currency which required a very good knowledge of counting and arithmetic. He travelled throughout the Middle East and along the way met mathematicians with whom he entered into serious discussions. He was familiar with the methods of Euclid and used those skills to bring to the European people mathematics in a very usable form. Unfortunately, today, Fibonacci's popularity does not encompass all of his discoveries but mainly focuses on one mathematical problem in Chapter 12 of *Liber Abaci,* which is the regeneration of rabbits, although its statement is a bit cumbersome it has resulted in a plethora of monumental ideas. The problem shows the monthly count of rabbits as the following sequence of numbers: 1,1,2,3,5,8,13,21,34,55,89,144,233,377,......... which is known today as the *Fibonacci numbers*.

Possibly best illustrated in the following way.

1
1
1 + 1 = 2
1 + 2 = 3
2 + 3 = 5
3 + 5 = 8
5 + 8 = 13
8 + 13 = 21
13 + 21 = 34
21 + 34 = 55
34 + 55 = 89
55 + 89 = 144
89 + 144 = 233
144 + 233 = 377
233 + 377 = 610
377 + 610 = 987
610 + 987 = 1,597. .

These numbers were not identified as anything special during the time Fibonacci wrote *Liber Abaci*. As a matter of fact, the famous German mathematician and Astronomer Johannes Kepler.[4] mention these numbers in a 611 publication, Centuries passed and the numbers still went unnoticed. In the 1830's C.F.Schimper and A.Braun noticed that the numbers appeared as the number of spirals of bracts on a pinecone.

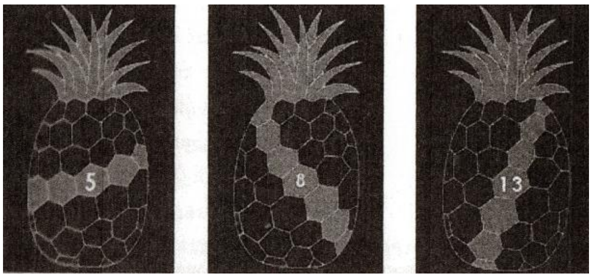
Johannes Kepler

The diversity of the phenomena of nature is so great and the treasures hidden in the heavens so rich, precisely in order that the human mind shall never be lacking in fresh nourishment. Johannes Kepler

In the mid 1800's the Fibonacci numbers began to capture the fascination of mathematicians. Francios Lucas (1842-1891) devised his own sequence of numbers by following the pattern set by Fibonacci. Instead of starting with 1,1,2,3.... Lucas thought of starting with 1,3,4,7,11..... so again we see another genius discovering a recursive relationship in numbers. To investigate further into how they both work and how they are used in higher mathematics would require some knowledge of higher mathematics which I admit I do not have, my aim is to show how the Fibonacci numbers occur, firstly in nature, in this section and in Architecture and Art in Geometry and in Music and in Astronomy.

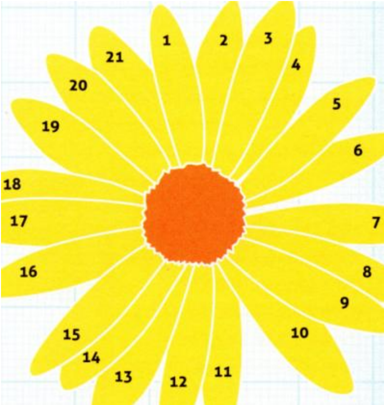
We will look at the Golden Ratio in detail in section on Geometry.

Perhaps you would be surprised to discover that the numbers also appear in the plant world. Take, for example the humble pineapple. If you were to get a pineapple you would find that the hexagonal bracts can be seen to form three different direction spirals. In figure 1, 2 & 3 you will notice that in the three direction there are 5, 8, and 13 spirals. These are three consecutive Fibonacci numbers.



1. 2. 3.

[4]Johannes Kepler (German: [ˈkɛplɐ]; December 27, 1571 – November 15, 1630) was a German mathematician, astronomer, and astrologer. A key figure in the 17th century scientific revolution, he is best known for his laws of planetary motion, based on his works *Astronomia nova*, *Harmonices Mundi*, and *Epitome of Copernican Astronomy*. These works also provided one of the foundations for Isaac Newton's theory of universal gravitation.



It is possible that many flowers have a Fibonacci number of petals. Take for instance the aster, it has 21 petals.

Iris, snowdrop, lily, trillium have 3 petals. Some lilies have 6 petals formed in two sets of 3.
Buttercup, wild rose, larkspur, apple blossom and hibiscus all have 5 petals.
Delphiniums have 8 petals.
Marigold, cineraria, and some daisies have 13 petals.
Aster, chicory and Helianthus have 21 petals.
Pyrethrums and other daisies have 34 petals.
Michaelmas daisies and other Compositae *(asteraceae family)* have 89 petals.

"The Laws of Nature are written in the language of mathematics".
Galileo Galilei.

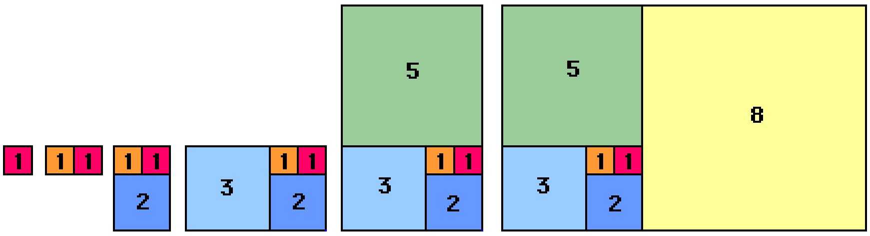
Trillium

Buttercup

Phi appears in petals on account of the ideal packing arrangement as selected by Darwinian processes; each petal is placed at 0.618034 per turn (out of a 360° circle) allowing for the best possible exposure to sunlight and other factors.

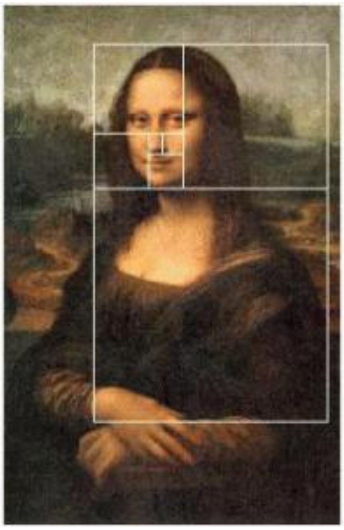
The next thing to examine is the unique properties of the Golden Rectangle. This shape, a rectangle in which the ratio of the sides a/b is equal to the golden mean (phi), can result in a nesting process that can be repeated into infinity — and which takes on the form of a spiral. It's call the logarithmic spiral, and it abounds in nature.

With the Fibonacci Sequence you can do what we described above for the Golden Rectangle. Start with a square and add a square of the same size to form a new rectangle. Continue adding squares whose sides are the length of the longer side of the rectangle; *the longer side will always be a successive Fibonacci number*. Eventually the large rectangle formed will look like a Golden Rectangle - the longer you continue, the closer it will be.

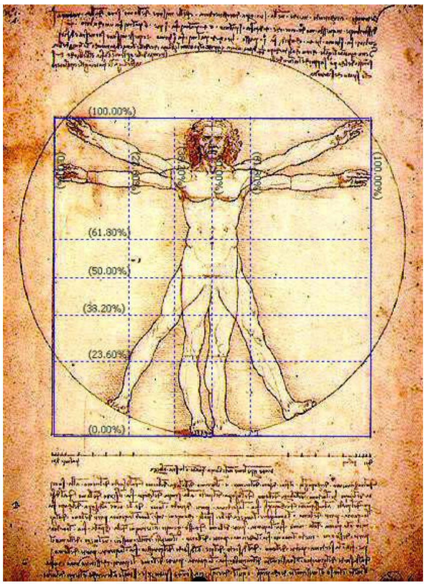


FIBONACCI SQUARES

So what is the significance firstly of the Golden Rectangle. It is found mainly in architecture and in Art even in the human form. It said to be the perfect form of creation both naturally and manmade. I will try to demonstrate it with illustrations.



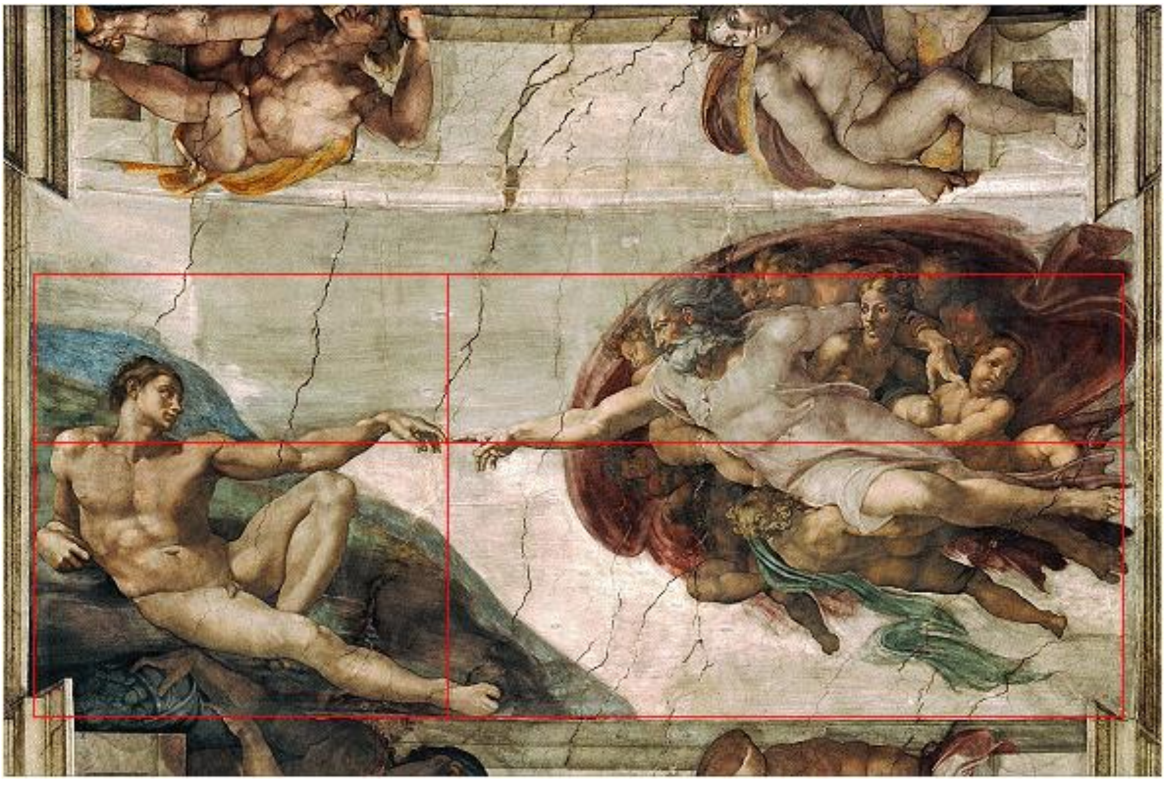
The first is the famous artist Leonardo Da Vinci who used it in many of his portraits. One very famous piece is the *Mona Lisa,* it is drawn according to the golden ratio. The golden ratio is 1:0.618 and has been coined golden because it is said to be aesthetically pleasing. The golden proportion can be found throughout the human body. The golden rectangle is simply a rectangle that reflects the golden ratio. As you can see by the illustration the painting has many golden ratios. If we look at the picture of Mona Lisa, the woman's face (width and length) equals to the golden ratio. "Mona Lisa" includes lots of golden rectangles. If we draw golden squares inside the golden rectangle, we can discover that the edges of squares are all on the important focal points of the woman, such as her chin, her eye, her nose, and the upturned corner of her mysterious mouth. It was believed that Leonardo Da Vinci applied mathematics to art.



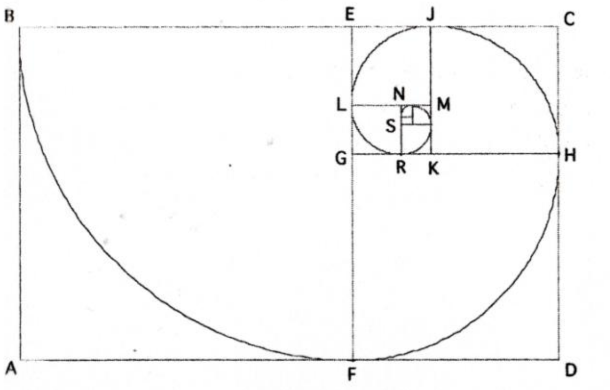
Da Vinci created other pieces that were also drawn according to the golden ratio such as The *Vitruvian Man,* or man of action. The height of the man is in golden proportion from the top of his head to his navel and from his navel to the bottom of his feet, so the Vitruvian Man illustrates all of the divine proportions within the human being.

The other paintings by Da Vinci include *The Last Supper and Old Man.*

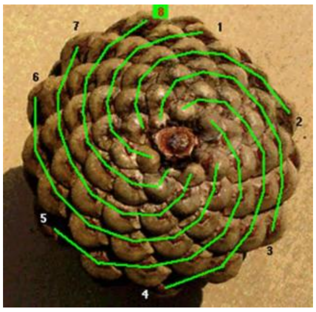
In Michelangelo's painting of "The Creation of Adam" (below) on the ceiling of the Sistine Chapel, look at the section of the painting bounded by God and Adam. The finger of God touches the finger of Adam precisely at the golden ratio point of the width and height of the area that contains them both. Alternatively, you can use the horizontal borders of the width of the painting and get the same result.



Now we will construct the spiral through the whole Golden Rectangle.



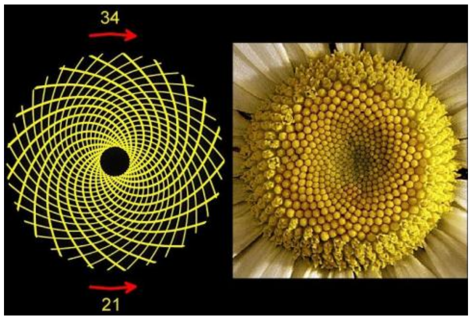
Starting at S which is the line between the first two squares, proceed to the right hand of the second square then down to R the side of the third square up to L the edge of the fourth square back up to J then to H, F and finishing with J.



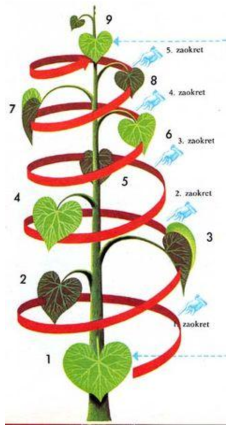
This now leads us into another phenomenon of the gold ratio, it is called the golden spiral or a logarithmic spiral.

Even more spectacularly, they appear in nature; for example, the number a spirals of bracts on a pinecone is always a Fibonacci number, and similarly, the number of bracts on a pineapple is also a Fibonacci number. The seed pods on a pinecone are arranged in a spiral pattern. Each cone consists of a pair of spirals, each one spiraling upwards in opposing directions. The number of steps will almost always match a pair of consecutive Fibonacci numbers. For example, a 3-5 cone is a cone which meets at the back after three steps along the left spiral, and five steps along the right.

It also appears in flowers. The head of a flower is also subject to a Fibonacci processes. Typically, seeds are produced at the center, and then migrate towards the outside to fill all the space. Sunflowers provide a great example of these spiraling patterns.



In some cases, the seed heads are so tightly packed that total number can get quite high — as many as 144 or more. And when counting these spirals, the total tends to match a Fibonacci number. Interestingly, a highly irrational number is required to optimize filling (namely one that will not be well represented by a fraction). Phi fits the bill rather nicely.



Having inspected the spiral in flowers we can now turn to the placement of leaves on a stem. Take a stem that has not been pruned and locate the lowest leaf. Begin with the bottom leaf, and count the number of rotations around the stem, each time going through the next leaf up the stem, until you reach the next leaf whose direction is the same as the first leaf identified (that is above it and pointing in the same direction). The number of rotations will be a Fibonacci number. Furthermore the number of leaves that you will pass along the way to reach the "final" leaf will also be a Fibonacci number.

In the figure opposite it took five revolutions to reach the leaf (the eight leaf) that is in the same direction as the first one. The phyllotaxis (i.e., leaf arrangement) will vary with different species, but, should be a Fibonacci number. The spiral is usually referred to as the "genetic spiral of a plant. *Source: The (Fabulous) Fibonacci Numbers.*

I have not tried to prove this but in my research I came across the article on the internet.

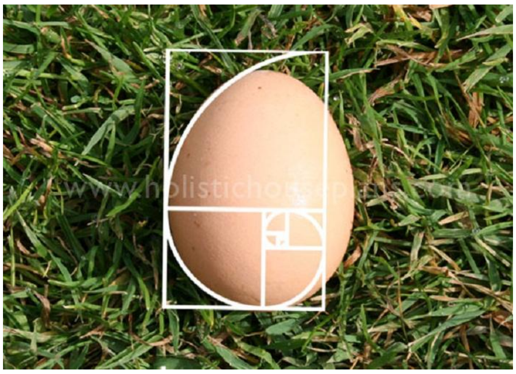
"One would be excused for suspecting that Aidan Dwyer, *(left)* said to be 13, is in fact a small, very young-looking, 37-year-old college-educated con-man of the highest order.

Such is not the case though for what the young Long Island lad has accomplished in a feat typically associated with much older individuals. As reported on the Patch community website out of Northport, N.Y., Aidan has used the Fibonacci sequence to devise a more efficient way to collect solar energy, earning himself a provisional U.S. patent and interest from "entities" apparently eager to explore commercializing his innovation. And you're wondering what the Fibonacci sequence is. Aidan explains it all on a page on the website of the American Museum of Natural History, which recently named him one of its Young Naturalist Award winners for 2011. The awards go to students from middle school through high school who have investigated questions they have in the areas of biology, Earth science, ecology and astronomy.

So back to the Fibonacci sequence: Starting with the numbers 0 and 1, each subsequent number is the sum of the previous two - 0, 1, 1, 2, 3, 5, 8, 13.... These numbers, when put in ratios, happens to show up in the patterns of branches and leaves on trees. Aidan, having been mesmerized by tree-branch patterns during a winter hike in the Catskills, sought to investigate why. His hunch: "I knew that branches and leaves collected sunlight for photosynthesis, so my next experiments investigated if the Fibonacci pattern helped."

One thing led to another, and before you know it, this kid, three years from being eligible for a driver's license, had built a tree-like stand affixed with small solar panels in the Fibonacci pattern. He compared its ability to collect sunlight to a flat-panel collector. And Nature won."

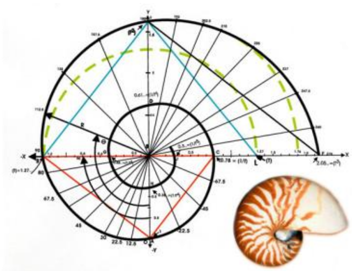
Summing up his research and imagining the possibilities, Aidan wrote: *"The tree design takes up less room than flat-panel arrays and works in spots that don't have a full southern view. It collects more sunlight in winter. Shade and bad weather like snow don't hurt it because the panels are not flat. It even looks nicer because it looks like a tree. A design like this may work better in urban areas where space and direct sunlight can be hard to find."* end of article.

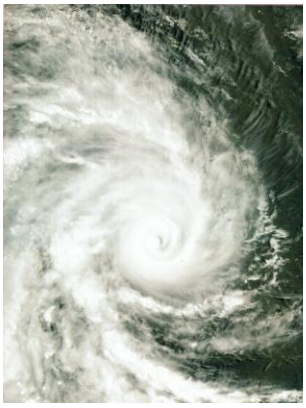


The spiral as it appears at the start of life.

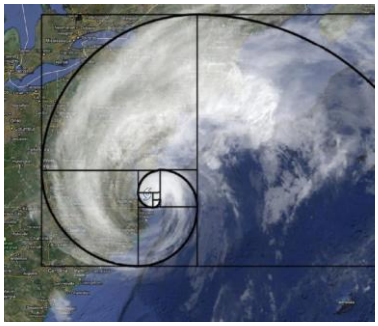
Other examples of the golden spiral in nature include snail shells and the nautilus shell.

Snail shells and nautilus shells follow the logarithmic spiral, as does the cochlea of the inner ear. It can also be seen in the horns of certain goats, and the shape of certain spider's webs.

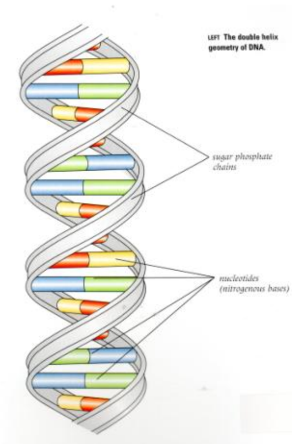


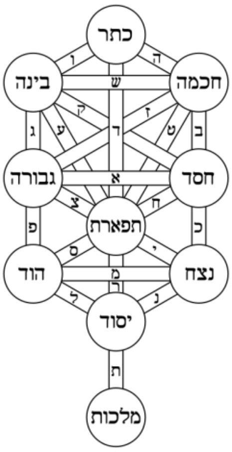


It even appears in the form of a hurricane.



It also appears in DNA which is composed of two right-handed 3-D helices. DNA combines into strands called chromosomes. DNA is like a spiral ladder with a series of rungs holding together the two strands. The DNA double helix requires ten rungs to make a complete turn- the **Kabbalistic Tree of Life** also has a ladder of ten rungs, and ten was Pythagoras' number of completion.





The **Tree of Life**, or *Etz haChayim (עץ החיים)* in Hebrew, is a classic descriptive term for the central mystical symbol used in the Kabbalah of esoteric Judaism, also known as the 10 Sephirot. Its diagrammatic representation, arranged in 3 columns/pillars, derives from Christian and esoteric sources and is not known to the earlier Jewish tradition. The tree, visually or conceptually, represents as a series of divine emanations God's creation itself *ex nihilo*, the nature of revealed divinity, the human soul, and the spiritual path of ascent by man. In this way, Kabbalists developed the symbol into a full model of reality, using the tree to depict a map of Creation.

Source: Sacred Geometry by Stephen Skinner.

We will again examine the Golden Spiral in the study on Geometry.

Perhaps the question should be asking now is how will the study of the science of arithmetic or the larger subject of Mathematics make me a better Mason? Is there anything more that we can learn that we do not already know? We know that there is such a thing as higher maths and have seen examples of this where a person, trying to solve a problem, uses a white board covered with an incredible number of formulas which mean absolutely nothing to us.

It has been said by the experts that we study mathematics for three basic reasons, calculation, application and also for inspiration. Perhaps for inspiration we can look back at the Fibonacci influence in nature.

Mathematics has been called the science of numbers and magnitude, the science of patterns and relationships. It is a growing, creative and dynamic field of enquiry, often hidden from the general population, but that is changing with the heart of such works as the Oscar winning film A Beautiful Mind and the Code Breaking story of World War II at Bletchley Park which reveal an appreciation of mathematical beauty.

Let us go back to when the liberal arts were first used as a method of education and when possibly higher maths was only just beginning to appear, what was the original intention for this particular subject?

Let us remember that the masons of that era were the equivalent to today's' civil engineers and when you look at what they achieved in their structures they must have had an incredible insight into mathematics. Everything they did required measurement or weighing. So it was imperative that they learn arithmetic as the basis of all their future leaning.

So is our need to study Arithmetic more about understanding how mathematics has a huge influence on the way we live, in on our day to day life and also how it impacts on the further study of Geometry, Astronomy and even to some extent Music. Arithmetic is really the A,B,C of so much we take for granted.

Possibly the other aspect to ponder as Freemasons is the use and symbolism of numbers in our Ritual and Masonic teaching. Everywhere we turn there are numbers with important signification, even this paper has a number as its main premise.

The symbolism which is derived from numbers was common to the Pythagoreans, the Kabbalists, the Gnostics, and all mystical associations. Allusions are to be found in all systems of religion; the Jewish Scriptures abound in it, and the Christians also show a share of its influence. It is not therefore surprising that the most predominant of all symbolism in Freemasonry is that of numbers.

The doctrine of numbers as symbols is most familiar to us because it formed the fundamental of the philosophy of Pythagoras. Yet it did not originate with him since he brought his theories from Egypt and the East where this numerical symbolism always prevailed.

The respect paid by Freemasons to certain numbers, all of which are odd, is founded not on the belief of any magical virtue, but because they are assumed to be the representative of certain ideas. That is to say, that a number is in Masonry is a symbol, and no more. The Masonic doctrine of numbers must not be confused with the doctrine of numbers which prevailed in other systems.

You may be surprised, as I was, as to the number of references to numbers and their symbolism which occurs in the fabric of Masonry as well as our ritual.

We take the first number "Three".

Not in any particular order the first is the "The Three Great Emblematical Lights in Freemasonry, The Square, The Compass and the Volume of the Sacred Law." being the first great truth the Candidate is shown on his initiation.

Then there are the Three Lesser Lights which are situated in the South, West and the East and represent the Sun, the Moon and the Master of the Lodge.

There are Three Great Pillars which support the Lodge, Wisdom, Strength and Beauty represented by the Ionic, Doric and Corinthian Columns.

Then, there the Three who rule the Lodge, the Master and his two Wardens and Three assistant officers.

There are Three movable Jewels and Three immovable Jewels in the Lodge.

In each Degree the number of working tools presented to the Candidate is of course Three.
The 24 inch gauge is divided into three distinct portions each with its own symbolic meaning.

In the First Degree we are taught about the Three principal moral virtues: Faith, Hope and Charity.

There are three steps in the first degree, 'three steps' is mentioned twice in the second degree, the latter in reference to the Winding Staircase. In the early days the first three steps of the Winding staircase were symbolic of the three stages of our life, Youth, Manhood and Old Age. And in the Third Degree there is the Third regular step in Freemasonry.

Then of course there are the first Three Degrees in Freemasonry, which are referred to as the Symbolic Degrees as every Freemason must attain these before any other rank may be attained and no man is exempt, and the highest Degree is the 33rd.

There is also Three recognised ways of being identified as a Freemason.

There are Three Grand Principals on which the Order is founded.

We are made a Freemason in a Lodge with Three distinct attributes. J,P,R.

And lastly there is the reference in the First Degree to the Three Grand Offerings.

The next number is Five. In Freemasonry five is a sacred number, inferior only in importance to Three and Seven. It is especially significant, in the Fellowcraft Degree, where Five are required to hold a Lodge. Five is again referred to when describing the Winding Staircase. In the Third Degree the reference is to the Five Points of Fellowship. Also Geometry which is firmly based on arithmetic and mathematic is the Fifth Science.

The next Number is Seven, which is the number that is the least number to be able to act as a Lodge and is symbolised by Seven Stars. This paper is about the Seven Liberal Arts and Sciences. There is also a reference to Seven steps in the Winding Staircase.

I am sure that there are others that I have missed but surely the number of references that I have included proves without doubt that numbers play a very important part in our life as a Mason.

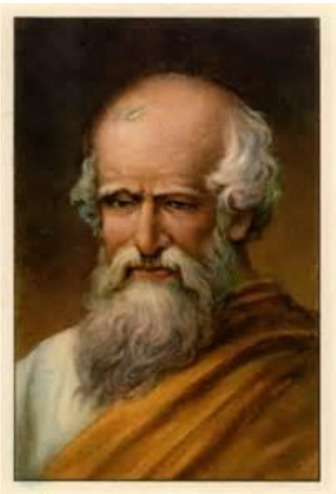
Geometry.

Geometry [Ancient Greek: *γεωμετρία*; *geo-* "earth", *-metron* "measurement"] is a branch of mathematics concerned with questions of shape, size, relative position of figures, and the properties of space. The term being originally equivalent to land measuring or surveying. The science of magnitude; that science which treats of the properties of lines, angles, surfaces, and solids; that branch of mathematics which treats of the properties and relations of magnitudes.

Source- The New Webster Encyclopaedic Dictionary

Geometry is so fundamentally a part of Freemasonry as to almost require no explanation, suffice to say, it is the science upon which our very fraternity is founded. It allows us to create right angled triangles, the symbol of our uprightness and square actions towards God, one another and our fellow creatures.

A mathematician who works in the field of geometry is called a geometer. Geometry arose independently in a number of early cultures as a body of practical knowledge concerning lengths, areas, and volumes, with elements of a formal mathematical science emerging in the West as early as Thales (6th Century BC). By the 3rd century BC geometry was put into an axiomatic form by Euclid, whose treatment, geometry, set a standard for many centuries to follow.



Archimedes developed ingenious techniques for calculating areas and volumes, in many ways anticipating modern integral calculus. The field of astronomy, especially mapping the positions of the stars and planets on the celestial sphere and describing the relationship between movements of celestial bodies, served as an important source of geometric problems during the next one and a half millennia. Both geometry and astronomy were considered in the classical world to be part of the Quadrivium, a subset of the seven liberal arts considered essential for a free citizen to master.

Archimedes

Practical geometry. Geometry originated as a practical science concerned with surveying, measurements, areas, and volumes. Among the notable accomplishments one finds formulas for lengths, areas and volumes, such as the Pythagorean theorem, circumference and area of a circle, area of a triangle, volume of a cylinder, sphere, and a pyramid. A method of computing certain inaccessible distances or heights based on similarity of geometric figures is attributed to Thales. Development of astronomy led to emergence of trigonometry and spherical trigonometry, together with the attendant computational techniques.

The introduction of coordinates by René Descartes and the concurrent developments of algebra marked a new stage for geometry, since geometric figures, such as plane curves, could now be represented analytically, i.e., with functions and equations. This played a key role in the emergence of infinitesimal calculus in the 17th century. Furthermore, the theory of perspective showed that there is more to geometry than just the metric properties of figures: perspective is the origin of projective geometry. The subject of geometry was further enriched by the study of intrinsic structure of geometric objects that originated with Euler and Gauss and led to the creation of topology and differential geometry.

from Wikipedia, the free encyclopaedia

The Oxyrhynchus papyrus showing fragment of Euclid's Elements
The manuscripts date from the 1st to the 6th century AD.

Euclid of Alexandria, [Greek *Eukleides* (born *c.* 300 BCE, Alexandria, Egypt)] is widely acclaimed as the father of Geometry. His book, or collection of books, the *Elements* was the authoritative text on geometry for over two thousand years and has been called the most successful textbook in the history of mathematics.

Geometry: In the modern rituals, geometry is said to be the basis on which the superstructure of Masonry is erected; and in the old Constitutions of the Medieval Freemasons of England the most prominent place of all the sciences is given to geometry, which is made synonymous with Masonry. Thus, in the Haliwell manuscript, which dates not later than the latter part of the fourteenth century, *"the Constitutions of the art of Geometry according to Euclid"*, the words geometry and Masonry being used indifferently throughout the document; and in the Harleian manuscript it is said, *"thus the craft Geometry was governed there, and that worthy Master (Euclid) gave it the name of Geometry, and it is called Masonrie in this land long after."* In another part of the same manuscript it is thus defined: *"The fifth science is called Geometry, and it teaches a man to mete, and measure of the earth and other things, which science is Masonrie."*

The Egyptians were undoubtedly one of the first nations who cultivated geometry as a science. *"It was not less useful and necessary to them, in the affairs of life, than agreeable to their speculatively philosophical genius. "* as Goguet observes, (Orig. des Lois, I.,iv.4,)

From Egypt, which was the parent of both of the sciences and the mysteries of the Pagan world, it passed over into other countries; and geometry and Operative Masonry have been together ever since. Operative Masonry carrying into execution those designs which were first traced according to the principles of Geometry.

Speculative Masonry is, in like manner, intimately connected with geometry. In deference to our operative ancestors, and, in fact, as a necessary result of our close connection with them, Speculative Freemasonry derives its most important symbols from this parent science. Hence it is not strange that Euclid, the most famous of geometricians, should be spoken of in all the Old Records as a founder of Masonry in Egypt, and that a special legend should have been invented in honour of his memory.

From Mackey's Masonic Encyclopaedia

Sacred geometry is the geometry used in the planning and construction of religious structures such as churches, temples, mosques, religious monuments, altars, tabernacles; as well as for sacred spaces such as *temenoi* or sacred groves, village greens and holy wells, and the creation of religious art. In sacred geometry, symbolic and sacred meanings are ascribed to certain geometric shapes and certain geometric proportions. According to **Paul Calter**[1]

In the ancient world certain numbers had symbolic meaning, aside from their ordinary use for counting or calculating; plane figures, the polygons, triangles, squares, hexagons, and so forth, were related to the numbers (three and the triangle, for example), were thought of in a similar way, and in fact, carried even more emotional value than the numbers themselves, because they were visual. The belief that God created the universe according to a geometric plan has ancient origins. Plutarch attributed the belief to Plato, writing *"Plato said God geometrizes continually"* (*Convivialium disputationum*, liber 8,2). In modern times the mathematician Carl Friedrich Gauss adapted this quote, saying *"God arithmetizes."* At least as late as Johannes Kepler (1571–1630), a belief in the geometric underpinnings of the cosmos persisted among scientists.

[1] Paul Calter B.S. in Engineering. The Cooper Union, New York, 1962, M.S. in Mechanical Engineering. Columbia University, 1966, M.F.A. in Sculpture. Vermont College of Norwich University, now the Vermont College of Fine Arts, 1993. Professor of Mathematics, Vermont Technical College, 1968 to 1989. Taught courses in mathematics, computer programming, and Geometry in Art & Architecture. Instructor on Vermont Interactive Television. Visiting Professor at Dartmouth College. Developed and taught course in Geometry in Art & Architecture funded by an NSF Grant for Mathematics Across the Curriculum Book Review Editor, Nexus Network Journal Editorial Board, Journal of Mathematics and the Arts.

Dr. Stephen Skinner is an internationally acclaimed Australian author and lecturer. His first profession was that of Geography Lecturer, at what is now the University of Technology in Sydney. He completed his Ph.D in Classics at the University of Newcastle. He is also the author of the book *Sacred Geometry*.

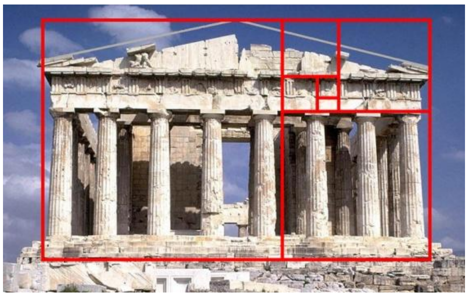
According to Dr. Stephen Skinner, the study of sacred geometry has its roots in the study of nature, and the mathematical principles at work therein. Many forms observed in nature can be related to geometry, for example, the "chambered nautilus" grows at a constant rate and so its shell forms a logarithmic spiral to accommodate that growth without changing shape. Also, honeybees construct hexagonal cells to hold their honey. These and other correspondences are seen by believers in sacred geometry to be further proof of the cosmic significance of geometric forms.

The term *"sacred geometry"* is used by archaeologists, anthropologists, and geometricians to encompass the religious, philosophical, and spiritual beliefs that have sprung up around geometry in various cultures during the course of human history. It is a catch-all term covering Pythagorean geometry and neo-Platonic geometry, as well as the perceived relationships between organic curves and logarithmic curves.

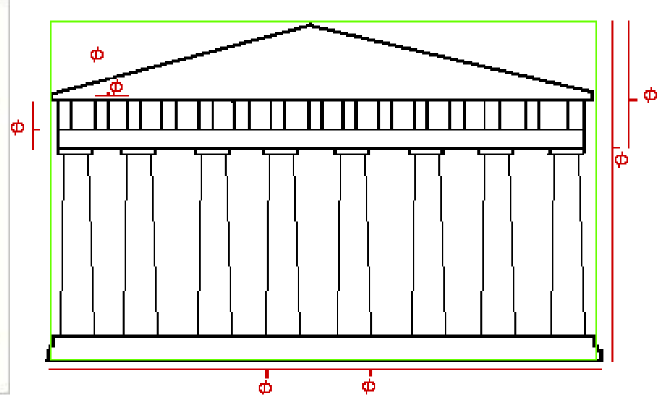
Here are a few examples of how the *"sacred"* has entered into geometry in different eras and cultures: The ancient Greeks assigned various attributes to the Platonic solids and to certain geometrically-derived ratios, investing them with *"meaning."* For example, the cube symbolized kingship and earthly foundations, while the Golden Section was seen as a dynamic principle embodying philosophy and wisdom. Thus a building dedicated to a god-king might bear traces of cubic geometry, while one dedicated to a heavenly god might have been constructed using Golden Section proportions.

The **Parthenon** is regarded as the finest example of Greek architecture is one such building. There are many other extraordinary examples of their genius with geometry, the slight diminution in diameter of the columns as they rise, though the observable effect on the Parthenon is considerably more subtle than on earlier temples It has a slight parabolic upward curvature intended to shed rainwater and reinforce the building against earthquakes. The columns might therefore be supposed to lean outwards, but they actually lean slightly inwards so that if they carried on, they would meet almost exactly a mile above the centre of the Parthenon. *"All follow the rule of being built to delicate curves"*. It is not universally agreed what the intended effect of these *"optical refinements"* was; they may serve as a sort of *"reverse optical illusion"*.

The Parthenon is therefore a perfect example of the Golden Section or Golden Ratio.



The golden rectangle is supposed to appear in many of the proportions of that famous ancient Greek temple, the Parthenon, in the Acropolis in Athens, Greece but there is no original documentary evidence that this was deliberately designed in.



Acropolis in Greek means "The Sacred Rock, the high city". All around the world the Acropolis of Athens is known as 'The Acropolis'. There are many Acropolises in Greece but the Acropolis of Athens is the best known. The Acropolis is primarily dedicated to the Goddess Athena. But humans from the prehistoric era have populated the Acropolis and the caves around it. Situated in the middle of Athens, many myths, festivals and important events are connected to the sacred Acropolis. The Acropolis echoes the grandeur and the power of the Athenian empire

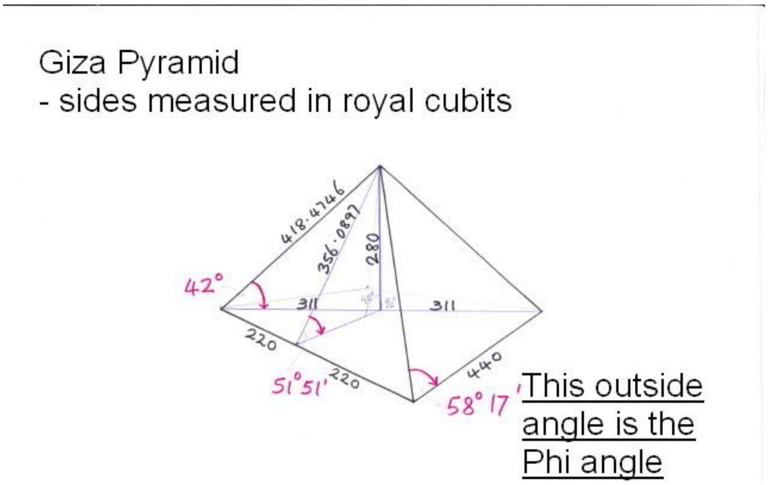
The Acropolis in the centre of Athens, is an outcrop of rock that dominates the ancient city. Its most famous monument is the Parthenon, a temple to the goddess *Athena* built around 430 or 440 BC. It is largely in ruins but is now undergoing some restoration. Again there are no original plans of the Parthenon itself. It appears to be built on a design of golden rectangles and root-5 rectangles: the front view *(see diagram above):* a golden rectangle, Phi times as wide as it is high the plan view: √5 as long as the front is wide so the floor area is a square-root-of-5 rectangle However, due to the top part being missing and the base being curved to counteract an optical illusion of level lines appearing bowed, these are only an approximate measures but reasonably good ones.

The **Great Pyramid of Giza** (also known as the **Pyramid of Khufu** or the **Pyramid of Cheops**) is the oldest and largest of the three pyramids in the Giza pyramid complex bordering what is now El Giza, Egypt. It is the oldest of the Seven Wonders of the Ancient World, and the only one to remain largely intact.

The accuracy of the pyramid's workmanship is such that the four sides of the base have an average error of only 58 millimetres in length. The base is horizontal and flat to within ±15 mm (0.6 in). The sides of the square base are closely aligned to the four cardinal compass points (within four minutes of arc) based on true north, not magnetic north, and the finished base was squared to a mean corner error of only 12 seconds of arc. The completed design dimensions, as suggested by Petrie's survey and subsequent studies, are estimated to have originally been 280 royal cubits high by 440 cubits long at each of the four sides of its base. The ratio of the perimeter to height of 1760/280 royal cubits equates to 2π to an accuracy of better than 0.05% (corresponding to the well-known approximation of π as 22/7).

Some Egyptologists consider this to have been the result of deliberate design proportion.

Miroslav Verner.

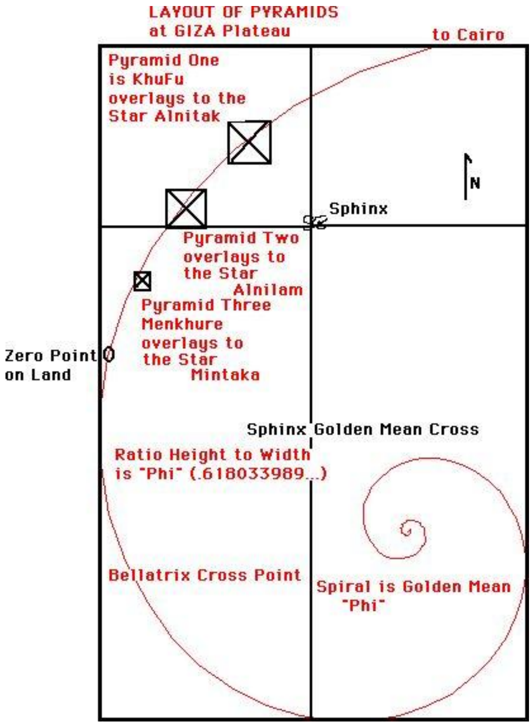


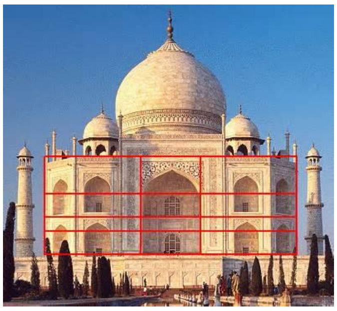
Verner [2] wrote, "We can conclude that although the ancient Egyptians could not precisely define the value of π, in practice they used it". Petrie, author of *Pyramids and Temples of Gizeh* concluded: "but these relations of areas and of circular ratio are so systematic that we should grant that they were in the builder's design".

[2] Miroslav Verner (born October 31, 1941 in Brno) is a Czech Egyptologist, who specializes in the history and archaeology of Ancient Egypt of the Old Kingdom. Verner was the director of the Czechoslovak and later Czech Institute of Egyptology at the Faculty of Arts, Charles University in Prague for twenty-five years, and led the Czech excavations at Abusir. He has also been associated with the Universities of Vienna and Hamburg as well as the Charles University in Prague and the American University in Cairo. Dr. Verner has been active in archaeological work since 1964, and he has been excavating at Abusir since 1976. In 1998, the tomb of Iufaa, an Egyptian priest and administer of palaces, was discovered in an unmolested tomb by a team of Czech archaeologists from the Czech Institute of Egyptology, under the direction of Verner. In 2005, Dr. Verner became the director of the project called "Investigation of the civilization of Ancient Egypt". The project runs from 2005 to 2011, and the aim is to study the evolution of Egyptian society throughout its history.

Others have argued that the Ancient Egyptians had no concept of Phi and would not have thought to encode it in their monuments. They believe that the observed pyramid slope may be based on a simple seked slope choice alone, with no regard to the overall size and proportions of the finished building. The Great Pyramid of Giza is a one of the examples that showing the existence of golden ratio in architecture. If we pretend there is a right triangle within the pyramid, the base of the right triangle above equals to 1 and the height equals to √1.618. Then, the hypotenuse of the right triangle will be 1.618. Therefore, we can say that the great pyramid of Giza is made out of the golden ratio. The Great Pyramid of Giza built around 2560 BC is one of the earliest examples of the use of the golden ratio. The length of each side of the base is 756 feet, and the height is 481 feet. So, we can find that the ratio of the base to height is 756/481=1.5717. The Rhind Papyrus of about 1650 BC includes the solution to some problems about pyramids, but it does not mention anything about the golden ratio Phi.

Another very interesting relationship between the Fibonacci numbers, the Golden spiral and the layout of the Pyramids as illustrated in the following diagram.





The main building of the Taj Mahal was designed using the Golden Ratio. This is why it looks so perfect. The rectangles that served as the basic outline for the exterior of the building were all in the Golden Proportion.

The Pantheon, in Rome shows clear golden sections in the placing of the three horizontal lines but the overall shape and the other prominent features are *not* golden

When Hindus (ancient and modern) plan to erect any edifice for religious purposes, from a small wayside shrine to an elaborate temple, they first perform a simple geometric construction on the ground, establishing due East and West and constructing a square there from. (It's a simple, elegant piece of work, at about the level of high school geometry). Upon this diagram they lay out the entire building. The making of this geometric construction is accompanied by prayers and other religious observances.

Perhaps the most significant building to be associated with the golden ratio, for the Freemason, is King Solomon's Temple. Solomon's reputation for wisdom is celebrated in Judaism, Christianity and Islam. So when he designed a temple for the Lord, we can safely assume he used the best and most sacred geometry. Fortunately, the Bible has left us with a detailed description of the temple dimensions.

Solomon turned to the old cultures of Phoenicia and Tyre to find the architects, masons, builders, craftsmen and even the materials he needed to build his Temple and erect a permanent sanctuary for the Ark of the Covenant. At that time, the Temple of Melquart in Tyre was one of the most magnificent temples in the region and it is extraordinary how closely its plan mirrors the Temple of Solomon.

The Temple was made of stone and lined with cedar panelling overlaid with gold. The innermost room, the Holy of Holies, was a cube exactly 20 cubits (34.4 feet or 10.5 meters) and partitioned off from the main body of the Temple. It contained two cherubim with two pairs of wings, each 5 cubits (8.5 feet or 2.6 meters) long. The wings touched both walls and the tips of each other's wings, and therefore had a combined span of 20 cubits.

An Artist's impression of what the room with the Ark of the Covenant may have looked like.

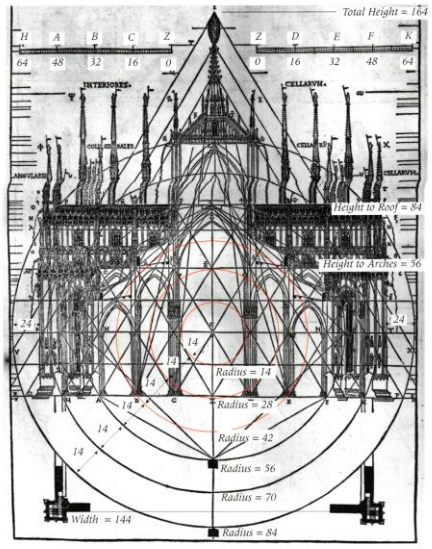
However the dimensions of the Temple itself are still a matter of debate, for if we take the Biblical dimensions at face value, the Temple was quite a modest size. Yet, the second building of the Temple used truly huge stones in its foundations which can be seen in Jerusalem today in the Wailing Wall which is hundreds of meters long. The paved area on top, which might reasonably be expected to correspond with the ground plan of the original temple is huge.

The Biblical dimensions are give in old cubits. Therefore, we assume that they are the same as royal cubits (20.620 inches 05 52.55 centimetres), the dimension revel a very small temple, but one that is astonishingly *six times higher* than it is wide. Length = 60 old cubits = 103.1 feet (31.4 meters). Breadth = 20 old cubits = 34.36 feet (10.5 meters). Height = 120 cubits = 206.2 feet (62.8 meters).

These are the exact measurements that the Templar's took back to Europe and subsequently influenced the building of the marvellous high ceiling Gothic cathedrals that date from this period.

Stephen Skinner believes that the only logical explanation is that the dimensions were at some stage inadvertently swapped. If so, the dimensions would have been; Length = 120 cubits, Breadth = 60 cubits and the Height = 20 cubits. which is a handsomely proportioned building where all the dimensions are multiple of each other and of the Holy of Holies.

An Artist's impression of the Temple.



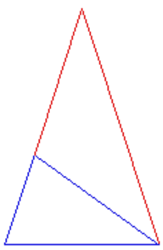
Milan Cathedral is a fine example of what the Templar's took back to Europe. The cathedral was designed originally by Caesar Caesariano in 1521, based on a series of evenly spaced concentric circles and a modulus of 12 and 7 units. During the building of the cathedral, several artists worked on the building, including Leonardo da Vinci.

Milan Cathedral after many changes of design.

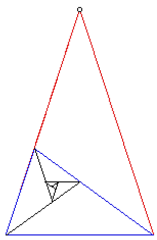
The Christian religion uses the cross as its major religious emblem, and in geometric terms this was elaborated during the Medieval period to the form of an unfolded cube (where the cube was equated with kingship). Many Gothic cathedrals were built using proportions derived from the geometry inherent in the cube and double-cube; this tradition continues in modern Christian churches to the present time.

The ancient Egyptians discovered that regular polygons can be increased while still maintaining the ratio of their sides by the addition of a strictly constructed area (which was later named the *"gnomon"* by the Greeks); the Egyptians assigned the concept of the ratio-retaining expansion of a rectangular area to the god Osiris, who was, therefore, often shown in ancient Egyptian frescoes seated on a square throne (square = kingship again) in which the original square and its L-shaped gnomon are clearly delineated, but the geometrical construction used to create the gnomon is not shown. It is, in fact, the absence of the attendant arcs and extension lines used in the creation of geometric forms that has led art historians and iconographers such a merry chase through history. It often takes the eye of a geometrician to spot the tell-tale signs of construction.

One of the best-known pieces of detective work in this regard was the discovery by Jay Hambidge, an art historian at Yale University during the 1920s, that the spirals on the Ionic column capitals of ancient Greek temples were laid out by the so-called *"whirling rectangle"* method for creation of a logarithmic spiral. **Jay Hambidge** (1867–1924) was a Canadian born American artist. He was a pupil at the Art Students' League in New York and of William Chase, and a thorough student of classical art. He conceived the idea that the study of arithmetic with the aid of geometrical designs was the foundation of the proportion and symmetry in Greek architecture, sculpture and ceramics. Careful examination and measurements of classical buildings in Greece, among them the Parthenon, the temple of Apollo at Bassæ, of Zeus at Olympia and Athenæ at Ægina, prompted him to formulate the theory of "dynamic symmetry"] as demonstrated in his works *Dynamic Symmetry: The Greek Vase* (1920) and *The Elements of Dynamic Symmetry* (1926). It created a great deal of discussion,] an English critic saying that Hambidge did not try to formulate a new theory, but to recover a lost technique.



Fig, 1



Fig, 2

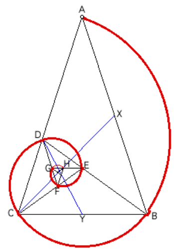


Fig.3

If we take the isosceles triangle that has the two base angles of 72 degrees and we bisect one of the base angles, we should see that we get another Golden triangle that is similar to the first. If we continue in this fashion we should get a set of Whirling Triangles (Figure 2 and 3). He realized this by examining numerous Ionic capitals in art museums until he located some in which the holes made by the placement of compass points had not been obliterated over time. One of these capitals was an unfinished, broken piece, dug up from a rubbish heap near a temple, it had apparently been damaged during manufacture and was discarded; its burial preserved it from the elements, and the marks of the geometric layout were remarkably clear upon it. No *"sacred meaning"* for the log spiral form of the Ionic column capital has been determined from Greek writings, but the use of other log spirals in Greek temple architecture, for instance in floor-block proportions and their placement in relation to overall floor area, indicates that Greek architects, unlike the Romans who came after them, deliberately constructed their temples according to *"whirling rectangle"* geometric ratios.

Designing the Sydney Opera House.

Ancient buildings are not the only ones to contain the golden ratio or the logarithmic spiral. The Sydney Opera House is reputed to have the essence of a complex structural and geometric problem showing clearly the use of organic curves. The following is the story of its controversial design by Jorn Utzon.

The engineer, Ove Arup, advised Utzon that his ***geometric*** shells could not be built. Nevertheless, Utzon's 'Red Book' of building designs was presented to the Opera House's Committee and to New South Wales Premier, Joe Cahill in January 1958. It featured lavish designs for the building, even though no-one yet knew how the shells might actually be built. The design model for the Sydney Opera House is part of the collection of personal papers presented by Professor Henry Ingram Ashworth (1907–1991), who was one of the judges in the international design competition and was involved in the building's construction.

It was the era before computer-aided design and the architectural model demonstrates how Utzon solved a design problem relating to the construction of his spectacular roof shells. The wooden model embodies Utzon's creative genius and offers a diversion from the common focus on the disputes surrounding the building. For his competition entry, Utzon envisaged that the roof would be constructed as concrete shells; however their configuration meant that this technique was structurally impossible at the time. Utzon had no real precedent to go on to design the roofs of the building. They were conceived as a number of ***parabolas*** supported by precast concrete. Utzon explored the terraced step design of Ancient Greek theatres and temples; he looked at the way Kornberg Castle, Helsingor, faced the Baltic Sea; and he examined ***vaulted arches*** found in ***Gothic churches***. Utzon studied buildings ranging from glasshouses, such as the Crystal Palace in London, to the prefabricated triangular ribs of the recently built Palazzetto dello Sport in Rome. One of his sketches for the engineer, Ove Arup, resembled ***waves rising and breaking on a beach.*** Another illustration showed inspiration coming from ***the ribbed fan shapes of palm leaves*** over a terraced floor. The design team experimented with forms for the shells, including ***circular ribs, ellipsoids and parabolas***. Utzon was fond of taking ***examples from nature*** for his designs, including shapes such as ***the smooth surface of an egg*** for the surface of the roof or the spreading shape of a Japanese fan to reflect the internal supports. Utzon's assistant, Helge Hjertholm, recalled that early one morning in 1961, Utzon came into his office with an orange. By slicing ***spherical triangles*** from the peel, he could create a variety of shells. Utzon realized ***all segments of his roof could be derived from a single sphere.*** The shell segments could be separated into individual components, prefabricated and then assembled on site. This would ensure that all the design elements contributed to the whole and created an ***intrinsic harmony.***

Architecture requires an ability to create harmony from all demands made by the undertaking, an ability to persuade them to grow together to form a new whole—as in nature; nature knows of no compromise, it accepts all difficulties ... merely as new factors which with no sign of conflict evolve into a whole.

The completion of the Sydney Opera House in 1973 marked a significant event in architectural history of the twentieth century. The Sydney Opera House was one of the first examples of the use of computer analysis to ***design complex geometric shapes***, and opened the way for more difficult building shapes to be constructed using computer-aided design, such as in the work of architect Frank Gehry and 'blob architecture' seen around the world.

In June 2007, the Sydney Opera House was added to the UNESCO World Heritage List, with the acknowledgment that 'Sydney Opera House stands by itself as one of the indisputable masterpieces of human creativity, not only in the twentieth century, but in the history of humankind'. Jørn Utzon was only the second living architect to have his work recognized in this way.

Note*: The key features of this story are highlighted in Italics throughout the piece, each relating back to the Logarithmic Spiral.*

Source: Teacher resources; National Library of Australia.

We cannot leave the subject of geometry without examining **Trigonometry**. The meaning of trigonometry comes from two Greek words *trigonon* (triangle) and *metron* (measure) - to measure the triangle. Its development spans all cultures, mostly due to the connection between trigonometry, astronomy and navigation and it still has many uses today - for example, in surveying and mapping. Around three millennia ago, the ancient Babylonians had a form of trigonometry, and it's from them that we take the idea of 360 degrees in a circle. They also gave us sixty minutes in a degree and sixty minutes in an hour, this was because the Babylonian numbering system was base sixty or sexagesimal and six, sixties were a full circle.

The Greeks worked with advanced trigonometry. Euclid and Archimedes developed theorems, via geometry which have trigonometric equivalents. The first trigonometric table is thought to have been compiled by the second-century BCE mathematician and astronomer, Hipparchus of Nicea and some call him the 'father of trigonometry'. The table was developed to aid in solving triangles, and Hipparchus is also credited with introducing the Greeks to the idea of 360 degrees in a circle.

Today there are a huge number of practical applications for trigonometry. As well as surveying and mapping, its put extensively to use in navigation. When thinking of navigation the sextant comes to mind and this further embeds the idea of the connection between geometry and astronomy, where the sailors used the constant relationship between the stars, or the sun and the horizon to determine the position at sea. Navigators find their position on the earth's surface by observing the location of the stars.

They need several things to do this:

- An angle-measuring instrument called a sextant, to measure the angle of the stars above the horizon.
- A chronometer for telling time.
- Accurate charts so the navigator can find the position of the ship in latitude and longitude or in reference to the land or a hazard such as rocks and shallow water called shoals.
- The navigator needs a quick and easy mathematical method for using the data from their observations of the stars to mark the position of the ship on the chart.

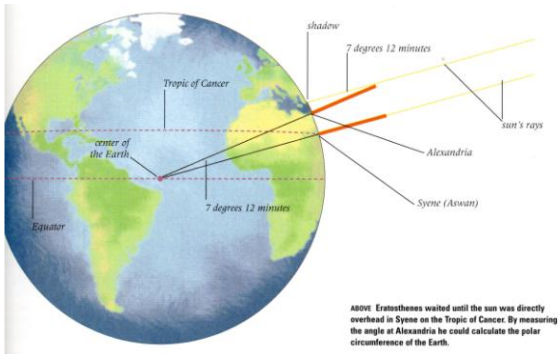
A brass Sextant.

An illustration of Satellite Navigation.

Satellite navigation uses the same basic principals but using satellites instead of stars and electronic methods instead of mechanical. The result is that it can be used in all weather and has pin-point accuracy A navigation or satnav system is a system of satellites that provide autonomous geo-spatial positioning with global coverage. A Satnav Satellite system allows small electronic receivers to determine their location (longitude, latitude, and altitude/elevation) to high precision (within a few meters) using time signals transmitted along a line of sight by radio from satellites. The signals also allow the electronic receiver to calculate the current local time to high precision, which allows time synchronization. A satellite navigation system with global coverage may be termed a global navigation satellite system (GNSS).

When I was reading Stephen Sinner's book on Sacred Geometry I was intrigued by a story entitled: Measuring the Earth with two sticks. After reading it I knew I had to include it here.

"Much of what modern science lays claim to was in fact discovered thousands of years ago, then lost during the Middle Ages. One of these facts is that the Earth is spherical, and the geometer concerned actually measured the circumference of the Earth to an incredible degree of accuracy using just two sticks.
When the French decided in the early 19th century to create the meter as their standard of length they based it upon one-40,000,000th of the circumference of the Earth. How were they going to do this? They followed a method that was no more sophisticated than the method of Eratosthenes (c275-194 BC), a Greek geometer living in Egypt more than 2,000 years previously.



Eratosthenes reasoned that, as the Earth was a sphere, he could use the Sun and the geometry of parallel lines to help measure the circumference of the Earth. He, or his assistants, travelled to the city of Syene, near modern day Aswan in Egypt, and found the spot where, exactly at noon on the summer solstice, about 21st June in the Northern Hemisphere, the Sun would be directly overhead. This is the moment when the Sun reaches its most northerly point in the year (it is marked by the Tropic of Cancer on modern maps) and a vertical rod casts no shadow.

At exactly the same moment, he measured the angle of the shadow cast by a rod in Alexandria, the northernmost city in Egypt where he was head librarian of the great library. The angle was 7 degree 12 minutes. The Sun's rays at both Syene and Alexandria are parallel and so, by using simple Euclidian geometry (as shown in the diagram right), he deduced that the angle made by the position of these cities with the centre of the Earth is also 7 degrees 12 minutes. Alexandria was 5,000 *stadia* from Syene, so he reasoned that:

If 7 degrees 12 minutes (i.e. 7.2 degrees) = 5,000 *stadia*, then 360 degrees (the Earth's circumference) = 5,000 x 360 / 7.2 = 250,000 *stadia*.

250,000 *stadia* is 24,461 miles or 30,186 km, which is a remarkably accurate measurement to have calculated for a man with two stick and a measuring wheel in two cities in ancient Egypt. Modern man, using all sorts of expensive technology, estimates the circumference of the Earth to be 24,891 miles or 39,875 km, just 1.7 percent difference. The French measurement, incidentally, was slightly wrong as they didn't take into account the slight flattening of the Earth at the North and South Poles".

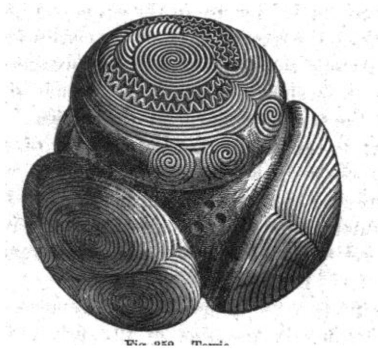
Before we look at a Timeline of Geometry, let me show you what I found. When I did this research I noticed the first line was about Scotland's Carved Stone Balls and I remembered hearing about them when we were at Skara Brae in the north of Scotland, so I went looking and found the following article, which I found to be both interesting and intriguing. I will attempt to give you a paraphrased version of the article.

The Carved Stone Balls of Scotland *Who made them, and why? by Jeff Nisbet*

Only about 400 of Scotland's 4,000-year-old carved stone balls have been found. They are fairly uniform in size, with the diameters of most measuring around 2.75 inches, fitting nicely into the cupped hand. They are made from a variety of stone, some from soft sandstone to hard granite. The number of projections or knobs range between three and 160, with six knobs being by far the most common. They display varying degrees of workmanship. A few like the remarkable Towie Stone. display beautiful intricate carvings, while others are unadorned. All but five of the stones have been found in Scotland.

The Neolithic village of **Skara Brae** lies on the shore of the Bay of Skaill on the west coast of Orkney's Mainland. Stunningly preserved structures containing stone furniture (dressers, beds, cupboards) dating back to 3200BC can be seen here. One of the resources that is lacking in Orkney is wood,there are almost no trees on the islands. As a result, other construction materials must be used. It comes as no great surprise to see the stone houses, but much of the furniture is still intact and there are stone beds and stone dressers against the house walls. There is evidence of habitation before the construction of the first stone houses which are still visible, as well as evidence that some houses were dismantled and others built during the course of the occupation of the village. Skara Brae was rediscovered after a storm, around 1850, dislodged much of the coastline in Skaill Bay. More remains may have disappeared into the sea. V.G.Childe began excavations of the site in 1927 and uncovered seven houses. The village was originally set some way back from the sea and was occupied by people who were farmers and who also hunted and fished. Pots and bone pins, necklace beads and carved stone balls and containers holding red ochre were all found on the site.

When the stones were found there were many theories as to how they were used, some proposed that they were attached to sticks and used as weapons, other said they were used as a standard of weight or perhaps used in throwing games. There was even a suggestion that they have been used by the Oracles to tell the future. The last theory was that they may have been used as "speaking stones" being passed to the next person to speak at a community meeting.



One example of a stone.

However Jeff Nisbbet came up with a rather interesting proposal.

To quote: Hanging on the wall of my home office is the brass and iron fire poker my father gave me before he died. very few other family keepsakes when we emigrated from Scotland to the USA in 1960, in spite of the fact that we would never again have to "poke up the fire" in a cold-water flat. It had clearly meant a lot to him, and it got me thinking ... He had made the poker, he said, as an "apprentice piece"- a requirement of his training as a British Railway "fitter."Railway fitters, especially during the Age of Steam, were often called upon to fashion parts for the huge locomotives out of raw metals, and his poker was a measure of his skill level at that time. The brass handle was made in the "thistle style," he added, and he had put a twist in the iron shaft for added strength.

I believe that as my father's poker verified, at its most basic level, my father's ability to work metals, so the carved stone balls of Scotland verified a mason's ability to work stone. As a 20th-century railway fitter, of course, my father didn't need his poker to find employment. He had a union card in his wallet that certified his proficiency in the trade, no matter where he looked for work. A Neolithic stonemason, on the other hand, would have needed some other type of certification, and an easily portable carved stone ball could have eminently suited that purpose. It is as true today as it was then, I would add, that the larger the population of a region the more available work there is. Besides the symbol stones and stone circles, there would have been houses and walls to build, cist burial slabs to cut, and tools and weapons to make -- all practical and marketable uses for the skilled stonemason's craft. Like the résumés and portfolios of today's workforce, the carved stone balls of the ancient stonemasons would be visible and tangible testimony of the work they were qualified to do. end of quote.

The Towie Stone

This article was permitted by the Society of Antiquaries of Scotland.

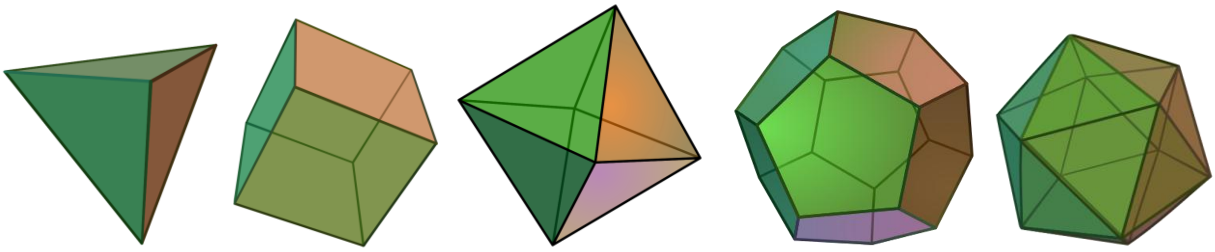
You may have wondered why I have included the carved stones in the section on geometry, well for two very good reasons, first their obvious relationship to stone masons of the middle ages and also to show how far back our history really reaches. The second because they relate to a major geometric concept, Plato's Platonic Solids.

The Carved Stone Balls have been taken as evidence of knowledge of the five Platonic solids a millennium before Plato described them. Indeed, some of them exhibit the symmetries of Platonic solids, but the extent of this and how much it depends on mathematical understanding is disputed, as configurations resembling the solids can naturally arise when placing knobs around a sphere.

Maybe a little more explanation of a Platonic Solid would help.

In three-dimensional space, a **Platonic solid** is a regular, convex polyhedron. It is constructed by congruent regular polygonal faces with the same number of faces meeting at each vertex or perhaps a simpler description. To be a Platonic solid an object must have congruent (equal) faces; these faces must only intersect at the edges; and the same number of faces must meet at each vertex (or point). Which means that no matter which face is down (or at the bottom) the shape will look the same.

Five solids meet those criteria, and each is named after its number of faces.



Tetrahedron *Hexahedron* *Octahedron* *Dodecahedron* *Icosahedron*
Four Faces *Six Faces* *Eight Faces* *Twelve Faces* *Twenty Faces*
(A Triangular Pyramid)

As we have already discovered the Platonic solids have been known since antiquity. Dice go back to the dawn of civilization with shapes that predated formal charting of Platonic solids.

The ancient Greeks studied the Platonic solids extensively. Some sources (such as Proclus) credit Pythagoras with their discovery. Other evidence suggests that he may have only been familiar with the tetrahedron, cube, and dodecahedron and that the discovery of the octahedron and Icosahedron belong to Theaetetus, a contemporary of Plato. In any case, Theaetetus gave a mathematical description of all five and may have been responsible for the first known proof that no other convex regular polyhedral exist.

Now the Timeline of Geometry.

Before 1000 BC

ca. 2000 BC — Scotland, Carved Stone Balls exhibit a variety of symmetries including all of the symmetries of *Platonic solids*.
1800 BC — Moscow Mathematical Papyrus, findings volume of a frustum.
1650 BC — Rhind Mathematical Papyrus, copy of a lost scroll from around 1850 BC, the scribe Ahmes presents one of the first known approximate values of π at 3.16, the first attempt at squaring the circle, earliest known use of a sort of cotangent, and knowledge of solving first order linear equations.

1st millennium BC

800 BC — Baudhayana, author of the Baudhayana Sulba Sutra, a Vedic Sanskrit geometric text, contains quadratic equations, and calculates the square root of 2 correct to five decimal places.
ca. 600 BC — the other Vedic "Sulba Sutras" ("rule of chords" in Sanskrit) use Pythagorean triples, contain of a number of geometrical proofs, and approximate π at 3.16
5th century BC — Hippocrates of Chios utilizes **lunes** [3] in an attempt to square the circle.
5th century BC — Apastamba, author of the Apastamba Sulba Sutra, another Vedic Sanskrit geometric text, makes an attempt at squaring the circle and also calculates the square root of 2 correct to five decimal places.
530 BC — Pythagoras studies propositional geometry and vibrating lyre strings; his group also discover the irrationality of the square root of two.
370 BC — Eudoxus states the method of exhaustion for area determination.
300 BC — Euclid in his *Elements* studies geometry as an axiomatic system, proves the infinitude of prime numbers and presents the Euclidean algorithm; he states the law of reflection in *Catoptrics*, and he proves the fundamental theorem of arithmetic.
260 BC — Archimedes proved that the value of π lies between 3 + 1/7 (approx. 3.1429) and 3 + 10/71 (approx. 3.1408), that the area of a circle was equal to π multiplied by the square of the radius of the circle and that the area enclosed by a parabola and a straight line is 4/3 multiplied by the area of a triangle with equal base and height. He also gave a very accurate estimate of the value of the square root of 3.
225 BC — Apollonius of Perga writes *On Conic Sections* and names the ellipse, parabola, and hyperbola,
150 BC — Jain mathematicians in India write the "Sthananga Sutra", which contains work on the theory of numbers, arithmetical operations, geometry, operations with fractions, simple equations, cubic equations, quartic equations, and permutations and combinations.
140 BC — Hipparchus develops the bases of trigonometry.

1st millennium

ca. 340 — Pappus of Alexandria states his hexagon theorem and his centroid theorem.
500 — Aryabhata writes the "Aryabhata-Siddhanta", which first introduces the trigonometric functions and methods of calculating their approximate numerical values. It defines the concepts of sine and cosine, and also contains the earliest tables of sine and cosine values (in 3.75-degree intervals from 0 to 90 degrees).
600s — Bhaskara I gives a rational approximation of the sine function.
700s — Virasena gives explicit rules for the Fibonacci sequence, gives the derivation of the volume of a frustum using an infinite procedure, and also deals with the logarithm to base 2 and knows its laws.
700s — Shridhara gives the rule for finding the volume of a sphere and also the formula for solving quadratic equations
820 — Al-Mahani conceived the idea of reducing geometrical problems such as doubling the cube to problems in algebra.
ca. 900 — Abu Kamil of Egypt had begun to understand what we would write in symbols as $x^n \cdot x^m = x^{m+n}$
975 — Al-Batani — Extended the Indian concepts of sine and cosine to other trigonometrical ratios, like tangent, secant and their inverse functions. Derived the formula: $\sin\alpha = \tan\alpha/\sqrt{1+\tan^2\alpha}$ and $\cos\alpha = 1/\sqrt{1+\tan^2\alpha}$.

1000–1500

ca. 1000 — Law of sines is discovered by Muslim mathematicians, but it is uncertain who discovers it first between Abu-Mahmud al-Khujandi, Abu Nasr Mansur, and Abu al-Wafa.
ca. 1100 — Omar Khayyám "gave a complete classification of cubic equations with geometric solutions found by means of intersecting conic sections." He became the first to find general geometric solutions of cubic equations and laid the foundations for the development of analytic geometry and non-Euclidean geometry. He also extracted roots using the decimal system (Hindu-Arabic numeral system).
1135 — Sharafeddin Tusi followed al-Khayyam's application of algebra to geometry, and wrote a treatise on cubic equations which "represents an essential contribution to another algebra which aimed to study curves by means of equations, thus inaugurating the beginning of algebraic geometry."
ca. 1250 — Nasir Al-Din Al-Tusi attempts to develop a form of non-Euclidean geometry.
15th century — Nilakantha Somayaji, a Kerala school mathematician, writes the "Aryabhatiya Bhasya", which contains work on infinite-series expansions, problems of algebra, and spherical geometry
17th century.
1600s – Putumana Somayaji writes the "Paddhati", which presents a detailed discussion of various trigonometric series.
1619 – Johannes Kepler discovers two of the Kepler-Poinsot polyhedra.

[3]A Lune, in geometry, is a crescent-shaped area on the surface of a plane or sphere defined by two semicircles whose common end points are diametrically opposed.

18th century

1722 – Abraham de Moivre states de Moivre's formula connecting trigonometric functions and complex numbers.
1733 – Giovanni Gerolamo Saccheri studies what geometry would be like if Euclid's fifth postulate were false.
1796 – Carl Friedrich Gauss proves that the regular 17-gon can be constructed using only a compass and straightedge.
1797 – Caspar Wessel associates vectors with complex numbers and studies complex number operations in geometrical terms.

19th century

1806 – Louis Poinsot discovers the two remaining Kepler-Poinsot polyhedra.
1829 – Bolyai, Gauss, and Lobachevsky invent hyperbolic non-Euclidean geometry.
1837 – Pierre Wanzel proves that doubling the cube and trisecting the angle are impossible with only a compass and straightedge, as well as the full completion of the problem of constructability of regular polygons.
1843 – William Hamilton discovers the calculus of quaternions and deduces that they are non-commutative.
1854 – Bernhard Riemann introduces Riemannian geometry.
1854 – Arthur Cayley shows that quaternions can be used to represent rotations in four-dimensional space.
1858 – August Ferdinand Möbius invents the Möbius strip.
1870 – Felix Klein constructs an analytic geometry for Lobachevski's geometry thereby establishing its self-consistency and the logical independence of Euclid's fifth postulate.
1873 – Charles Hermite proves that e is transcendental.
1878 – Charles Hermite solves the general quintic equation by means of elliptic and modular functions.
1882 – Ferdinand von Lindemann proves that π is transcendental and that therefore the circle cannot be squared with a compass and straightedge.
1882 – Felix Klein invents the Klein bottle.
1899 – David Hilbert presents a set of self-consistent geometric axioms in ***Foundations of Geometry.***

20th century

1901 – Élie Cartan develops the exterior derivative.
1905 – Einstein's theory of special relativity.
1912 – Luitzen Egbertus Jan Brouwer presents the Brouwer fixed-point theorem.
1916 – Einstein's theory of general relativity.
1930 – Casimir Kuratowski shows that the three-cottage problem has no solution.
1931 – Georges de Rham develops theorems in **cohomology[4]** and characteristic classes.
1933 – Karol Borsuk and Stanislaw Ulam present the Borsuk-Ulam antipodal-point theorem.
1955 – H. S. M. Coxeter et al. publish the complete list of uniform polyhedron.
1975 – Benoit Mandelbrot, fractals theory.
1981 – Mikhail Gromov develops the theory of hyperbolic groups, revolutionizing both infinite group theory and global differential geometry.
1983 – The classification of finite simple groups, a collaborative work involving some hundred mathematicians and spanning thirty years, is completed.
1991 – Alain Connes and John Lott develop non-commutative geometry.
1998 – Thomas Callister Hales (almost certainly) proves the Kepler conjecture.

21st century

2003 – Grigori Perelman proves the Poincaré conjecture.
2007 – A team of researches throughout North America and Europe used networks of computers to map E8 mathematics.

[4]In mathematics, specifically in homology theory and algebraic topology, **cohomology** is a general term for a sequence of abelian groups associated to a topological space, often defined from a cochain complex. Cohomology can be viewed as a method of assigning richer algebraic invariants to a space than homology. Some versions of cohomology arise by dualizing the construction of homology. In other words, cochains are functions on the group of chains in homology theory.

Music.

I would like to dedicate this chapter to the Late Wor Bro John Henriksen,PDGOrg, a wonderful musician, mentor and a true friend.

Music is a mystery to the Freemason and a mystery as to its connection to mathematics, but as anyone, who practices this art, the connection is apparent. Our ancient brother Pythagoras was perhaps the first to notice the mathematical correlation between music and numbers.

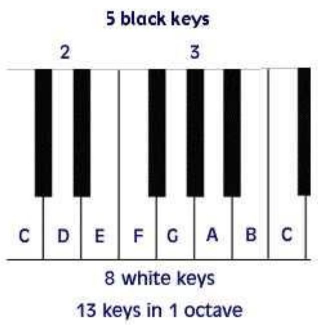
music, noun [Fr. *musique*, L. *musica*, from Gr. *mousikē* (technē, art, understood), music, art, culture. MUSE.] a succession of sounds so modulated as to please the ear; melody or harmony; the art of producing melody or harmony; the written or printed score of a composition. *The New Webster Encyclopaedic Dictionary*

Music. One of the seven liberal arts and sciences, whose beauties are inculcated in the Fellowcraft Degree. Music is recommended to the attention of Masons, because as the "concord of sweet sounds" elevates the generous sentiment of the soul, so should the concord of good feeling reign among the brethren, that by the union of friendship and brotherly love and harmony exist throughout the Craft. *From Mackey's Masonic Encyclopaedia*
"

Music expresses that which cannot be put into words and that which cannot remain silent"
― Victor Hugo

Music. [from the Greek *mousike,* "(art) of the Muses"] is an art form whose medium is sound organized in time. Music theory also relies considerably on mathematics, number theory and the laws of arithmetic. We have already examined the Fibonacci Numbers in mathematics, geometry, architecture and nature; so I now want to show their relevance to music.

The first example is found in the Fibonacci numbers: When we look at the keys on the piano we notice they are arranged in a rather unusual way. Some are white and some are black. The white notes are full notes where the black notes are both sharp and flat.



The Fibonacci series, as it appears in music, has a foundation in the series, as: There are 13 notes in the span of any note through its octave. A scale is composed of 8 notes, of which the 5th and 3rd notes create the basic foundation of all chords, and are based on a tone which are combination of 2 steps and 1 step from the root tone, that is the 1st note of the scale.

Note also how the piano keyboard scale of C to C above of 13 keys has 8 white keys and 5 black keys, split into groups of 3 and 2.While some might “note” that there are only 12 “notes” in the scale, if you don’t have a root and octave, a start and an end, you have no means of calculating the gradations in between, so this 13th note as the octave is essential to computing the frequencies of the other notes. The word “octave” comes from the Latin word for 8 (octō), referring to the eight tones of the complete musical scale, which in the key of C are C-D-E-F-G-A-B-C.

In a scale, the dominant note is the 5th note of the major scale, which is also the 8th note of all 13 notes that comprise the octave. This provides an added instance of Fibonacci numbers in key musical relationships. Interestingly, 8/13 is .61538, which approximates phi. What’s more, the typical three chord song in the key of A is made up of A, its Fibonacci & phi partner E, and D, to which A bears the same relationship as E does to A. This is analogous to the “A is to B as B is to C” basis for the golden section, or in this case “D is to A as A is to E.”
Musical frequencies are based on Fibonacci ratios.

Notes in the scale of western music are based on natural harmonics that are created by ratios of frequencies. Ratios found in the first seven numbers of the Fibonacci series (0, 1, 1, 2, 3, 5, 8) are related to key frequencies of musical notes.

Fibonacci Ratio	Calculated Frequency	Tempered Frequency	Note in Scale	Musical Relationship	When A=432 *	Octave below	Octave above
1/1	440	440.00	A	Root	432	216	864
2/1	880	880.00	A	Octave	864	432	1728
2/3	293.33	293.66	D	Fourth	288	144	576
2/5	176	174.62	F	Aug Fifth	172.8	86.4	345.6
3/2	660	659.26	E	Fifth	648	324	1296
3/5	264	261.63	C	Minor Third	259.2	129.6	518.4
3/8	165	164.82	E	Fifth	162 (Phi)	81	324
5/2	1,100.00	1,108.72	C#	Third	1080	540	2160
5/3	733.33	740.00	F#	Sixth	720	360	1440
5/8	275	277.18	C#	Third	270	135	540
8/3	1,173.33	1,174.64	D	Fourth	1152	576	2304
8/5	704	698.46	F	Aug. Fifth	691.2	345.6	1382.4

The invention of the modern piano is credited to Bartolomeo Cristofori (1655–1731) of Padua, Italy, who was employed by Ferdinando de' Medici, Grand Prince of Tuscany, as the Keeper of the Instruments; he was an expert harpsichord maker, and was well acquainted with the body of knowledge on stringed keyboard instruments. It is not known exactly when Cristofori first built a piano. An inventory made by his employers, the Medici family, indicates the existence of a piano by the year 1700; another document of doubtful authenticity indicates a date of 1698. The three Cristofori pianos that survive today date from the 1720s. So if the Piano was only invented in the 1720's and the Fibonacci numbers were only being re- investigated in the 1800's we can safety say that the sequence is natural in music as it is in nature. The effect of the Fibonacci Numbers is also found in the use of the golden section used by composers mainly in two areas of the compositional process. The first relates to the location of the climax and the second relates to form.

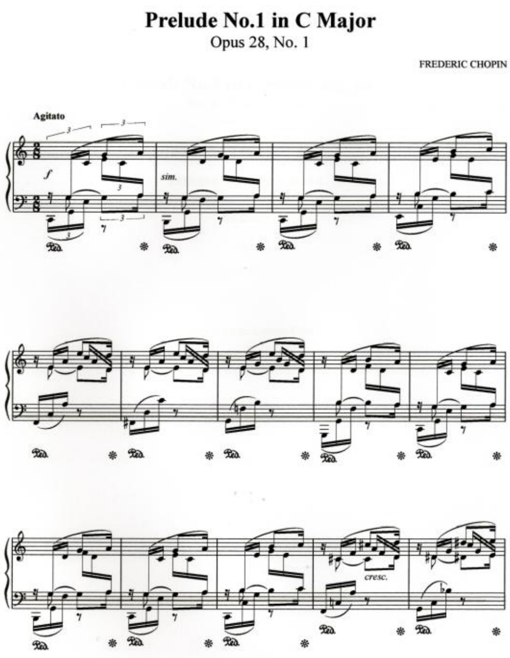
Let us look at some of Chopin's Preludes. His book contains twenty four of the most extraordinary musical miniatures, each one a world unto itself. The first of these is based on an interesting game that Chopin is playing with himself.

Frédéric François Chopin.

"If I were not a physicist, I would probably be a musician. I often think in music. I live my daydreams in music. I see my life in terms of music."

– A lbert Einstein

The piece is constructed on two dramatic arches of differing sizes. The melody begins on the notes G-A and rises to E-D on measure 5, where it remains for three measures and then descends back to the G-A in measure 9. From here the melody rises even further and climaxes on the D-C in measure 21, then it begins its decent to the G-A in measure 25 at which point it leaps twice to E-D before coming to rest on five C's with A-G pairs below them. The wonderful climax of this miniature piece comes exactly in measure 21 at the golden section of its 34 measures. Yes they are true members of the Fibonacci sequence. The same exact placement of the climax occurs in Prelude No.9 in E Major. Not all preludes have a climax exactly on the golden section but most occur very close



This is what the actual piece looks like.

If you would like to hear the effect go to Google, type in Chopin's Prelude No.1 and then go to U Tube and there will be a piece you can listen to.

Mozart also used the golden section in composing his piano sonatas. Of his 18 sonatas numbers 1,2 7,10,15 and16 use exactly the golden section and five others are extremely close. Haydn's sonatas contained three, which used the golden section but over all his other compositions were much closer than Mozart's.

Mozart.

Beethoven's Fifth Symphony, Wagner's Prelude to Tristan and Isolde and Bartok's Music for Strings, Percussion and Celesta all contain aspects of the golden section please refer to the book by Alfred S. Posamentier & Ingmar Lehmann, Tje (Fabulous) Fibonacci Numbers. published by Prometheus Books which was the source of the section of the paper. The music section was written by Dr. Stephen Jablonsky, Professor of Music and Chair of the Music Department at the City College of the City University of New York.

Harmony. [Latin and Greek: *harmonia,* from Greek *harmos*, a suiting or fitting together a joint, from *arō,* to fit, to adapt.] The just adaptation of parts to each other, in any system or combination of things, or in things intended to form a connected whole; concord; consonance; concord or agreement in facts, views, sentiments, manners, interests, and the like; peace and friendship; *mus*. musical concord; the accordance of two or more sounds, or that union of different sounds which pleases the ear, or a succession of such sounds called chords; the science which treats such sounds. *The New Webster Encyclopaedic Dictionary*.

Pythagoras and the Pythagoreans were very interested in music, being musician as well as mathematicians.

Pythagoras.

Iamblichus.

Iamblichus[1], the fourth-century scholar who wrote nine books about the Pythagorean sect, describes how Pythagoras came to discover the underlying principles of musical harmony.

Once when he was engrossed in the thought of whether he could devise a mechanical aid for the sense of hearing which would prove both certain and ingenious. Such an aid would be similar to the compasses, rules and optical instruments designed for the sense of sight. Likewise the sense of touch had scales and the concept of weights and measures. By some divine stroke of luck he happened to walk past the forge of a blacksmith and listened to the hammers pounding iron and producing a variegated harmony of reverberations between them, except for one combination of sounds. According to Iamblichus, Pythagoras immediately ran into the forge to investigate the harmony of the hammers. He noticed that most of the hammers could be struck simultaneously to generate a harmonious sound, whereas any combination containing one particular hammer always generated an unpleasant noise. He analyzed the hammers and realized that those who were harmonious with each other had a simple mathematical relationship, their masses were simple ratios or fractions of each other. That is to say that hammers half, two-thirds, or three-quarters the weight of a particular hammer would all generate harmonious sounds. On the other hand, the hammer that was generating disharmony when struck along with any of the other hammers had a weight that bore no simple relationship to the other weights. Pythagoras had discovered that simple numerical ratios were responsible for harmony in music.

[1]Iamblichus, also known as **Iamblichus Chalcidensis**, (ca. 245 C.E.- ca. 325 C.E., Greek: Ἰάμβλιχος) was a Neo-Platonist philosopher who determined the direction taken by later Neo-platonic philosophy, and influenced Jewish, Christian and Islamic theology. A student of Porphyry, he played an important role in the transmission of Platonic ideas into the thought of the Middle Ages and the Renaissance. Iamblichus established a Neo-platonic curriculum which was followed for the next two centuries. To the Neo-platonic theory developed by Plotinus, he introduced modifications such as the detailed elaboration of its formal divisions, a more systematic application of Pythagorean number-symbolism, and a mythic interpretation of cosmological hierarchy. He departed from his Neo-platonic predecessors, who regarded matter as corrupt, by declaring matter to be as divine as the rest of the cosmos.

Using simple fractions, Pythagoras produced the notes that we know today. If you have a string and pluck it to produce a **C** then shorten the string to half its length it will produce a frequency that is twice as big, in other words, an octave higher.

Note	String Length
C	1
D	8/9
E	4/5
F	3/4
G	2/3
A	3/5
B	8/15
C	1/2

Source: Awesome Algebra by Michael Willers. Published by Archimedes Press.

From the beginning in Masonry the terms of music and harmony have been interchangeable and although in some cases they can mean the same they can also have a very divergent meaning. Even today, in some Lodges the provision of music in the ceremony is referred to as harmony. However it does have that other meaning of peace and concord and even in the first Degree the candidate is prevented from bringing anything into the lodge *"to disturb its harmony."*

Harmony[2]: It is a duty especially entrusted to the Senior Warden of a Lodge, who is figuratively supposed to preside over the Craft during the hours of labour, so to act that none shall depart from the lodge dissatisfied or discontented, that harmony may be thus preserved, because, as the ritual expresses it, harmony is the strength and support of all well regulated institutions.

From Mackey's Masonic Encyclopaedia

Music is a higher revelation
than all wisdom and philosophy.
Music is the electrical soil
in which the spirit lives, thinks and invents."
ff Ludwig van Beethoven ff

From the very beginning operative masons and music have been closely related. They built the grand Cathedrals and churches where music as we know it today really started to make its mark. They built the castles where the musicians and composers were patronised and the first public performances were held, and later the magnificent Concert Halls and Opera Houses where music thrived and was enjoyed by the populace. Then with the advent of philosophical masons or Freemasonry they used the music to enhance their rituals and improve their lives. They realised the power of music, it inspires and sooths the soul of man. It has the power of love and peace it can inspire our patriotism and make us proud of our heritage. There is also a mystical essence to music. One of the most important roles of music has played, down through the ages, has been to glorify God.

Every part of society has embraced music in one way or another from School Bands to Military Bands small music groups to huge Symphony Orchestras, each playing a part in our life.

[2] The subject of music within the Quadrivium was originally the classical subject of harmonics, in particular the study of the proportions between the music intervals. Music as actually practiced (i.e. producing or playing music as an artistic expression) was not part of this study, but the framework of classical harmonics would influence the content and structure of music theory as practiced both in European and Islamic cultures.

Do you know that our soul
is composed of harmony?"
- Leonardo DaVinci -

The early Freemasons used music to a far greater effect in their rituals than what is done today. They took music from Grand Opera, the Classics and the Church and blended it to suit their ritual needs. We can see the effects of this in our Grand Lodge ceremonies of today. For the ordinary Lodge they wove music into each of the degrees and every part of the ceremony was uplifted by the inclusion of music.

In a book of Music for Lodge Organists, (at a cost of 4 shillings, to give you some idea of its age) there are 13 Odes in the First Degree, 10 Odes in the Second Degree 11 Odes in the Third Degree as well as marches and Odes for the Installation ceremony.

Music today can bring a ceremony to life, can lift the sense of feeling and inject it with light good humour or deep contemplation, such is the power of music.

"Music gives a soul to the universe,
wings to the mind,
flight to the imagination,
and life to everything."
Plato

Let us now look at a brief history of music to help understand where we stand with music today.

Medieval Period 0-1400 A.D.

The Middle Ages.

The traditions of Western music can be traced back to the social and religious developments that took place in Europe during the Middle Ages, the years roughly spanning from about 500 to 1400 A.D. Because of the domination of the early Catholic Church during this period, sacred music was the most prevalent. Beginning with Gregorian Chant, sacred music slowly developed into a polyphonic music called *organum* performed at Notre Dame in Paris by the twelfth century. Secular music flourished, also, in the hands of the French *trouvères* and *troubadours*, until the period culminated with the sacred and secular compositions of the first true genius of Western music, Guillaume de Machaut.

Music had been a part of the world's civilizations for hundreds of years before the Middle Ages. Primitive cave drawings, stories from the Bible, and Egyptian hieroglyphs all attest to the fact that people had created instruments and had been making music for centuries.

The word *music* derives from the ancient Greek *muses*, the nine goddesses of art and science. The first study of music as an art form dates from around 500B.C., when Pythagoras experimented with acoustics and the mathematical relationships of tones. In so doing, Pythagoras and others established the Greek *modes*: scales comprised of whole tones and half steps.

The 9 Muses are dancing while Apollo is playing the lyre

When we explore Medieval music, we are dealing with the longest and most distant period of musical history. Saint Gregory is credited with organizing the huge repertory of chant that developed during the first centuries of the Christian Church, hence the term Gregorian chant.

He was Pope from 590 to 604, and the Medieval era continued into the 1400's. One of the principal difficulties in studying Medieval music is that a system of notating music developed only gradually. The first examples of musical notation date from around 900. For several centuries notation only indicated what pitch, or not to sing. The system for notating rhythm started in the 12th or 13th century.

Gregorian Chant: the early Christian church derived their music from existing Jewish and Byzantine religious chant. Like all music in the Western world up to this time, plainchant was *monophonic*: that is, it comprised a single melody without any harmonic support or accompaniment. The many hundreds of melodies are defined by one of the eight Greek *modes*, some of which sound very different from the major/minor scales our ears are used to today. The melodies are free in tempo and seem to wander melodically, dictated by the Latin liturgical texts to which they are set. As these chants spread throughout Europe , they were embellished and developed along many different lines in various regions and according to various sects. It was believed that Pope GregoryI codified them during the sixth-century, establishing uniform usage throughout the Western Catholic Church. Although his actual contribution to this enormous body of music remains unknown, his name has been applied to this music, and it is known as *Gregorian Chant*.

Gregorian chant remains among the most spiritually moving and profound music in Western culture. An idea of its pure, floating melody can be heard in the Easter hymn *Victimae paschali laudes*. Many years later, composers of Renaissance *polyphony* very often used plainchant melodies as the basis for their sacred works.

"If I should ever die, God forbid, let this be my epitaph:
The only proof he needed for the existence of God was music."
- Kurt Vonnegut -

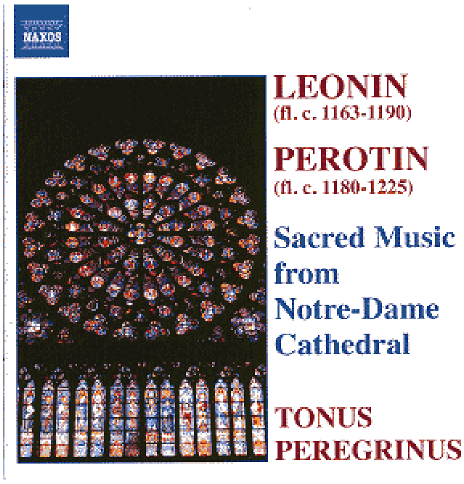
Renaissance Period 1400-1600 A.D.

In the mid-1500s, a prominent bishop commented, that music composed for the church should reflect the meaning of the words so that the listeners would be moved to piety. To suggest that Medieval composers had no desire to write "expressive" music would be unfair. But, it was the rediscovery of ancient Greek ideals in the Renaissance that inspired many musicians to explore the eloquent possibilities of their art. The increased value of individualism in the Renaissance is reflected by the changing role of the composer in society. Unlike most of their Medieval predecessors, the great masters of the Renaissance were revered in their own lifetimes. The technique of printing music, while slow to evolve, helped in the preservation and distribution of music and musical ideas. Sacred music was still predominant, though secular music became more prevalent and more sophisticated. The repertory of instrumental music also began to expand significantly. New instruments were invented, including the clavichord and virginal, both keyboard instruments, and many existing instruments were improved. Masses and motets were the primary forms of sacred vocal *polyphony*.

Notre Dame and the *Ars Antiqua*

Sometime during the ninth century, music theorists in the Church began experimenting with the idea of singing two melodic lines simultaneously at parallel intervals, usually at the fourth, fifth, or octave. The resulting hollow-sounding music was called *organum* and very slowly developed over the next hundred years. By the eleventh century, one, two, and much later, even three, added melodic lines were no longer moving in parallel motion, but contrary to each other, sometimes even crossing. The original chant melody was then sung very slowly on long held notes called the *tenor* , from the Latin *tenere*, meaning, *to hold,* and the added melodies wove about and embellished the resulting drone. This music thrived at the Cathedral of Notre Dame in Paris during the twelfth and thirteenth centuries, and much later became known as the *Ars Antiqua*, or the "old art."

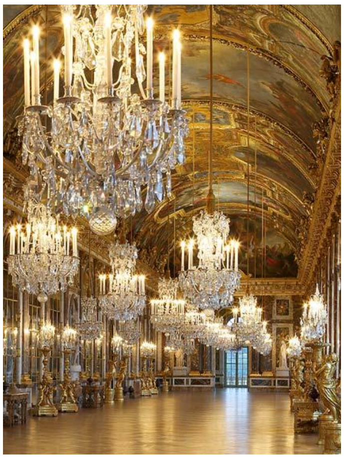
The two composers at Notre Dame especially known for composing in this style are Léonin (fl. ca. 1163-1190), who composed organa for two voices, and his successor Pérotin (early 13th century), whose organa included three and even four voices. Pérotin's music is an excellent example of this very early form of *polyphony* (music for two or more simultaneously sounding voices), as can be heard in his setting of *Sederunt principes*. This music was slowly supplanted by the smoother contours of the polyphonic music of the fourteenth century, which became known as the Ars Nova.



Baroque Period 1600-1750 A.D.

If one relates musical periods to architecture, the Medieval period might be symbolized by Notre Dame Cathedral in Paris, the Renaissance by the Duomo in Florence, and the Baroque by Louis XIV's palace at Versailles. Baroque music is often highly ornate, colourful and richly textured when compared with its predecessors. Opera was born at what is considered to be the very beginning of the Baroque era, around 1600.

Duomo (Cathedral of Santa Maria dei Fiori)



The Hall of Mirrors, The Palace of Versailles.

This unique form combines poetry, theatre, the visual arts and music. It came about because a group of Italian intellectuals wanted to recapture the spirit of ancient Greek drama in which music played a key role. The first great opera was **Orfeo,** by Claudio Monteverdi, first performed in 1607. Music's ability to express human emotions and depict natural phenomenon was explored throughout the Baroque period. Vivaldi's famous set of concertos, **The Four Seasons**, is a famous example.

Antonio Vivaldi.

Although imitative polyphony remained fundamental to musical composition, homophonic writing became increasingly important. Homophonic[3] music features a clear distinction between the melody line and a subsidiary accompaniment part. This style was important in opera and other solo vocal music because it focused the listener's attention on the expressive melody of the singer. The homophonic style gradually became prevalent in instrumental music as well. Many Baroque works include a continuo part in which a keyboard (harpsichord or organ) and bass instrument (cello or bassoon) provide the harmonic underpinning of chords that accompanies the melodic lines. New polyphonic forms were developed, and as in the Renaissance, composers considered the art of counterpoint (the crafting of polyphony) to be essential to their art. Canons and fugues, two very strict forms of imitative polyphony, were extremely popular. Composers were even expected to be able to improvise complex fugues on a moment's notice to prove their skill. The orchestra evolved during the early Baroque, starting as an "accompanist" for operatic and vocal music.

[3] Homophonic: Relating to part music in which the parts move together in simple harmonization.

By the mid-1600s the orchestra had a life of its own. The concerto was a favourite Baroque form that featured a solo instrumentalist (or small ensemble of soloists) playing "against" the orchestra, creating interesting contrasts of volume and texture. Many Baroque composers were also virtuoso performers. For example, Archangelo Corelli was famous for his violin playing and Johann Sebastian Bach was famous for his keyboard skills. The highly ornamented quality of Baroque melody lent itself perfectly to such displays of musical dexterity.

Johann Sebastian Bach

Classical Period 1750-1800 A.D.

The word Classical has strong connotations, conjuring up the art and philosophy of Ancient Greece and Rome along with their ideals of balance, proportion and disciplined expression. The late Baroque style was polyphonically complex and melodically ornate. The composers of the early Classical period changed direction, writing music that was much simpler in texture. It is in some ways ironic that two of J.S. Bach's children, Carl Philipp Emanuel (C.P.E.) and Johann Christian (J.C.), were among the leaders of this new artistic movement. Their father had been the greatest master of the high Baroque style, and it was his children who made that style obsolete. Homophony, music in which melody and accompaniment are distinct, dominated the Classical style, and new forms of composition were developed to accommodate the transformation. Sonata form is by far the most important of these forms, and one that continued to evolve throughout the Classical period. Although Baroque composers also wrote pieces called sonatas, the Classical sonata was quite different. The essence of the Classical sonata is conflict. A highly simplified example of such a conflict might be between two themes of contrasting character. This contrast would be intensified during the course of the sonata, then finally resolved.

In some ways, there is a resemblance to the skeleton of a play, we meet characters, a conflict is developed and finally a resolution reached. Sonata form allowed composers to give pure instrumental music a recognizable dramatic shape. Every major instrumental form of the Classical era, including the string quartet, symphony and concerto was moulded on the dramatic structure of the sonata. One of the most important developments of the Classical period is the growth of the public concert. Although the aristocracy would continue to play a significant role in musical life, it was now possible for composers to survive without being the employee of one person or family. This also meant that concerts were no longer limited to palace drawing rooms. Composers started organizing concerts featuring their own music, and often attracted large audiences. The increasing popularity of the public concert had a strong impact on the growth of the orchestra. Although chamber music and solo works were played in the home or other intimate settings, orchestral concerts seemed to be naturally designed for big public spaces. As a result, symphonic music. including opera and oratorio, became more extroverted in character. Composers gradually expanded the size of the orchestra to accommodate this expanded musical vision.

Romantic Period 1800-1900 A.D.

Just as the word "Classical "conjures up certain images, Romantic is at least as vocative. The Classical period focused on structural clarity and emotional restraint. Classical music was expressive, but not so passionate that it could overwhelm a work's equilibrium. Beethoven who was in some ways responsible for igniting the flame of romanticism, always struggled, sometimes unsuccessfully, to maintain that balance.

Ludwig van Beethoven

Many composers of the Romantic period followed Beethoven's model and found their own balance between emotional intensity and Classical form. Others revelled in the new atmosphere of artistic freedom and created music whose structure was designed to support its emotional surges. Musical story-telling became important, and not just in opera, but in *"pure"* instrumental music as well. The tone-poem is a particularly Romantic invention, as it was an orchestral work whose structure was entirely dependent on the scene being depicted or the story being told. Colour was another important feature of Romantic music. New instruments were added to the orchestra and composers experimented with ways to get new sounds from existing instruments.

A large palette of musical colours was necessary to depict the exotic scenes that became so popular. Exoticism was something of a 19th century obsession. Russian composers wrote music depicting Spanish landscapes, Nicolai Rimsky-Korsakov's Capriccio Espagnol, for example, and German composers wrote music depicting Scottish landscapes, such as Mendelssohn's Scottish Symphony. Operas were set in exotic locales, Verdi's Aïda is set in Ancient Egypt.

In addition to seeking out the sights and sounds of other places, composers began exploring the music of their native countries. Nationalism became a driving force in the late Romantic period and composers wanted their music to express their cultural identity. This desire was particularly intense in Russia and Eastern Europe, where elements of folk music were incorporated into symphonies, tone-poems and other "Classical" forms. The Romantic period was the heyday of the virtuoso. Exceptionally gifted performers, and particularly pianists, violinists, and singers, became enormously popular. Liszt, the great Hungarian pianist/composer, reportedly played with such passion and intensity that women in the audience would faint. Since, like Liszt, most composers were also virtuoso performers, it was inevitable that the music they wrote would be extremely challenging to play. The Romantic period witnessed an unprecedented glorification of the artist, whether musician, poet or painter, that has had a powerful impact on our own culture.

Contemporary Period 1900-Present

Why do musical styles change? The *"evolution"* of music is at least partly shaped by the influence one composer has on another. These influences are not always positive, however. Sometimes composers react against the music of their recent past (even though they might admire it) and move in what seems to be the opposite direction. For example, the simplified style of the early Classical period was almost certainly a reaction to the extreme intricacies of the late Baroque. The late Romantic period featured its own extremes: sprawling symphonies and tone-poems overflowing with music that seemed to stretch harmony and melody to their limits. It is certainly possible to view some early 20th century music as an extension of the late Romantic style, but a great deal of it can also be interpreted as a reaction against that style. 20th century music is a series of "isms" and "neo-isms." The primal energy of Stravinsky's Rite of Spring has been called neo-Primitivism. The intensely emotional tone of Schonberg's early music has been labelled Expressionism. The return to clearly structured forms and textures has been dubbed neo-Classicism. These terms have been employed in an attempt to organize the diversity of styles running through the 20th century.

Nationalism continued to be a strong musical influence in the first half of the century. The study of folk songs enriched the music of numerous composers, such as Ralph Vaughan Williams (England), Bela Bartok (Hungary), Heitor Villa Lobos (Brazil) and Aaron Copland (USA). Jazz and popular musical styles have also been tremendously influential on "classical" composers from both the United States and Europe. Technology has played a increasingly important role in the development of 20th century music. Composers have used recording tape as a compositional tool, such as Steve Reich's Violin Phase.

Ralph Vaughn Williams.

Electronically generated sounds have been used both on their own and in combination with traditional instruments. More recently, computer technology has been used in a variety of ways, including manipulating the performance of instruments in real time.

Adapted from papers published by Oracle Education Foundation and Music History 102 Designed , compiled by Robert Sherrane.

Astronomy

Astronomy the seventh of the Liberal Arts and Sciences in Freemasonry.

The Sir Thomas Brisbane Planetarium.
Brisbane, Queensland.

First we will look at it as one of the Liberal Arts subjects and its relationship to Freemasonry, then I want to look at the history of astronomy and its development over the centuries, then we will look at what is happening today and finally try to work out what it means to us today, as Freemasons.

The word astronomy comes from the Greek words *astron,* a star, and *nomos,* a law or rule. It is the science which treats of the celestial bodies, their nature, magnitudes, motions, distances, periods of revolution etc.
The New Webster Encyclopaedic Dictionary.

From the Freemason's perspective Astronomy is that art by which we can trace the great symmetry of the hand of the deity throughout the heavens. Many of our symbols, the sun, the moon the stars are borrowed from the science of astronomy.

Also it must be noted that astronomy and geometry are closely related as the whole of the universe is geometrically precise. Over the years of recorded history, little has changed, the stars and planets retain their geometrical relationship to each other and to earth so that their precision can be measured and used for navigation.

Historically, astronomy has included disciplines as diverse as **meteorology**, the study of the weather.

Celestial navigation in oceanic trade and exploration, the making of calendars and documenting historical facts, and even divining the future as in **astrology**.

In ancient thinking, it was considered to be the discipline of the motion of all objects through space and time. Astronomy and astrology were also critical to the study of philosophy and theology, as everything divine or spiritual came down from the heavens, without it, what was left was considered as *"earthly"* and profane.

Astronomy is the science which instructs us in the laws that govern the heavenly bodies. Its origin is lost in the mists of antiquity; for the earliest inhabitants of the earth must have been attracted by the splendour of the glorious firmament above them, and would have sought in the motions of its luminaries for the easiest and most certain method of measuring time. With astronomy the system of Freemasonry is intimately connected.

From that science many of our most significant emblems are borrowed. The Lodge itself is a representation of the world; it is adorned with the images of the sun and moon, whose regularity and precision furnish a lesson of wisdom and prudence; its pillars of strength and establishment have been compared to the two columns which the ancients placed at the equinoctial **[ek-qui-nok-tial]** points as supporters of the arch of heaven; the blazing star, which was among the Egyptians a symbol of Anubis, or the dogstar.

The blazing star in Freemasonry is **Sirius.**

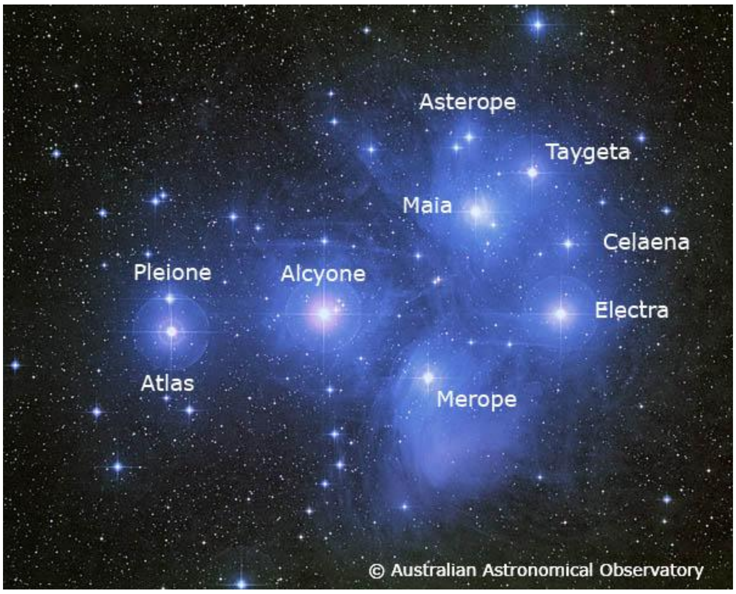
Sirius is the brightest star in the night sky, it is almost twice as bright as Canopus, the next brightest star. The name "Sirius" is derived from the Ancient Greek: Σείριος *Seirios* meaning "glowing" or "scorcher". The star has the Bayer designation Alpha Canis Majoris. What the naked eye perceives as a single star is actually a binary star system, consisting of a white main-sequence star termed **Sirius A**, and a faint white dwarf companion called **Sirius B**.

Sirius.

Sirius appears bright because of both its intrinsic luminosity and its proximity to Earth. The Sirius system is one of Earth's near neighbors; for the Northern-hemisphere observers between 30 degrees and 73 degrees of latitude, it is the closest star, after the Sun, that can be seen with the naked eye. Sirius is gradually moving closer to the Solar System, so it will slightly increase in brightness over the next 60,000 years. After that time its distance will begin to recede, but it will continue to be the brightest star in the Earth's sky for the next 210,000 years.

Sirius A is about twice as massive as the Sun and has an absolute visual magnitude of 1.42. It is 25 times more luminous than the Sun. The system is between 200 and 300 million years old. Sirius is also known as the "**Dog Star**", reflecting its prominence in its constellation, Canis Major or Greater Dog. The rising of Sirius in conjunction with the rising of the Sun marked the flooding of the Nile in Ancient Egypt and marked the "dog days" of summer for the ancient Greeks, while to the Polynesians it marked winter and was an important star for navigation around the Pacific Ocean.

Then to quote the First Degree Tracing Board: "The covering of a Freemason's Lodge is a celestial canopy of divers colours, even the Heavens." Researchers believe that the celestial canopy referred to, is actually decorated with the beautiful **Pleiades**.



The Pleiades are one of the finest and nearest examples of a reflection nebula associated with a cluster of young stars. The cluster itself is a group of many hundreds of stars about 400 light years away in the direction of the northern constellation of **Taurus.** It is a handful of the brightest stars clustered together in space and have been recognised as a group since ancient times. However, even the brightest of the Pleiades stars, Alcyone, is relatively faint and would be inconspicuous and nameless if it were not a member of the cluster. The faintest named star, Asterope, is close to the threshold of naked eye visibility. All the visible stars of the Pleiades are in reality much more luminous than the Sun. Source- Anglo Australian Observatory.

The Pleiades.

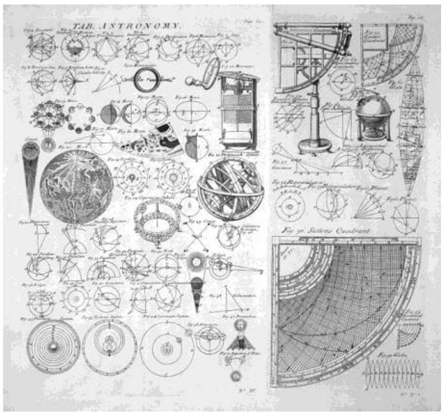
Many of the ancient religions had the moon as a major symbol however the adoption of the Moon in the Masonic system as a symbol is for an entirely different reason.

Masons retained her image in their Rites, because the Lodge is a representation of the universe,

where, **as the Sun rules over the day,**

the moon presides over the night; as the one regulates the year; so does the other the months, and as the former is the King of the starry hosts of heaven, so is the latter the Queen; but both deriving their heat and light and power from Him (God) who. as the third and the greatest light, the master of heaven and earth, controls them both.

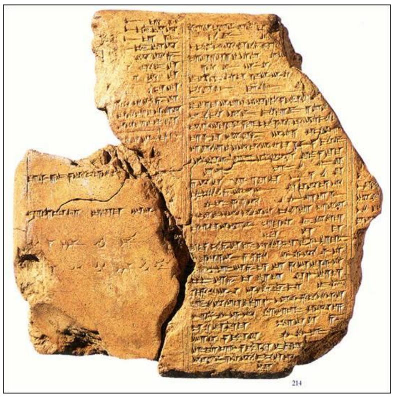
From Mackey's Masonic Encyclopaedia



Astronomy is generally reckoned to be the oldest of the sciences. Most ancient civilisations practised something that we would recognise as astronomy; the first applications of mathematics to the understanding of the natural world involved astronomy.

Astronomy also played a very large part in the foundation of *"modern science"* in the 17th century - the so-called *"Scientific Revolution"* is often considered to have begun with the publication of Copernicus' *De Revolutionibus* in 1543, which saw the reintroduction of heliocentric cosmology.

Copernicus.



During the 1870's and early 1880's numerous clay tablets from Babylonian archaeological sites found their way to Bagdad. The tablets were found in the ruins of the ancient Assyrian city of Nineveh, part of the royal archive from the most famous library in the ancient near East (the Library of Ashurbanipal). One set of seventy tablets revealed a vast program of astronomical observation, which had been carried out in the second millennium BC during the old Babylonian Period. Most tablets dealt with interpretations of lunar and solar eclipses, conjunctions of planets and comets, which the Babylonians took as dangerous omens. Others were concerned with planets and stars. What these tablets reveal is an unexpected link with an ancient scientific community dating back to before 1000BC.

Source: The Universe by J.P.McEvoy.

One of the Babylonian clay tablets.

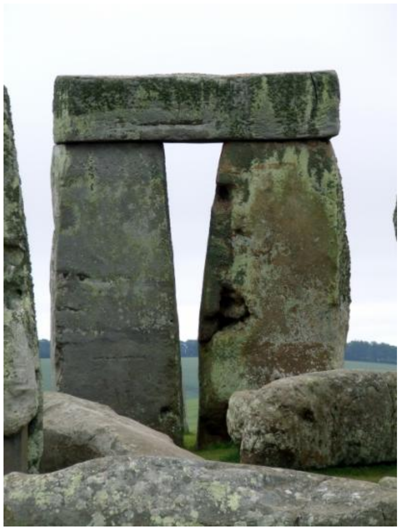
The main motivation for modern astronomy is without a doubt human curiosity. We all want to know 'where we came from? and how did the world begin?'

The history of astronomy spans a vast period of time but in that time opinions have also vastly changed.

From the very earliest time of civilisation we see the way people have used astronomy in relation to religion and in their everyday life. The earliest example of this is from approximately **3500BC to 2000BC** when the astronomically aligned monuments of Stonehenge and Newgrange were built.

Stonehenge is perhaps the most famous prehistoric monument in the world. Begun as a simple earthwork enclosure, it was built in several stages, with the unique lintelled stone circle being erected in the late Neolithic period around **2500BC**. Stonehenge remained important into the early Bronze Age, when many burial mounds were built nearby.

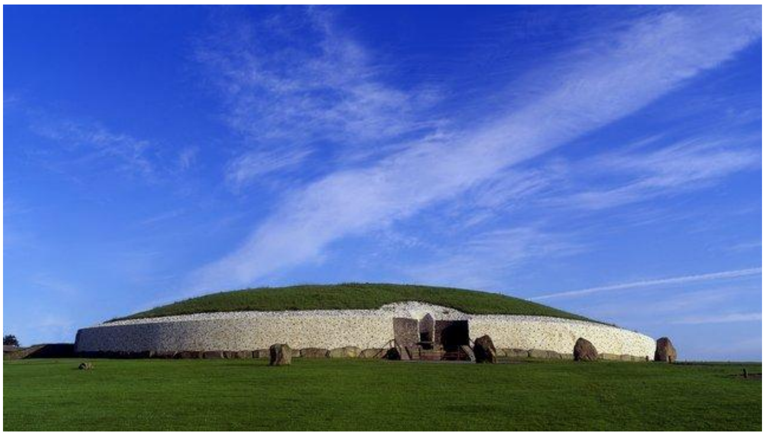
When you actually see Stonehenge and understand the enormity of how it was built, the size and weight of the stones and how they were put together defies understanding and then to realise that in **2000BC** it was perfectly astrologically aligned to both the winter solstice and the summer solstice.

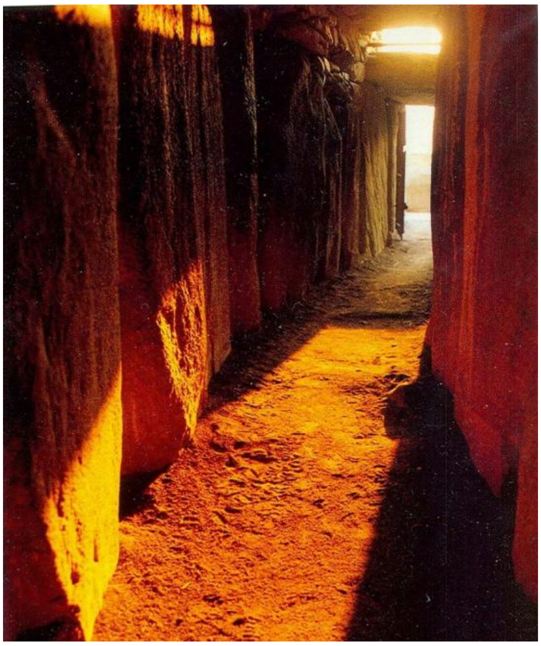


Newgrange was constructed over **5,000** years ago, about **3,200BC**, making it older than Stonehenge in England and the Great Pyramid of Giza in Egypt.

Newgrange was built during the Neolithic or New Stone Age by a farming community that prospered on the rich lands of the Boyne Valley in Ireland. Knowth and Dowth are similar mounds that together with Newgrange have been designated a World Heritage Site by UNESCO. Archaeologists classified Newgrange as a passage tomb, however Newgrange is now recognised to be much more than a passage tomb.

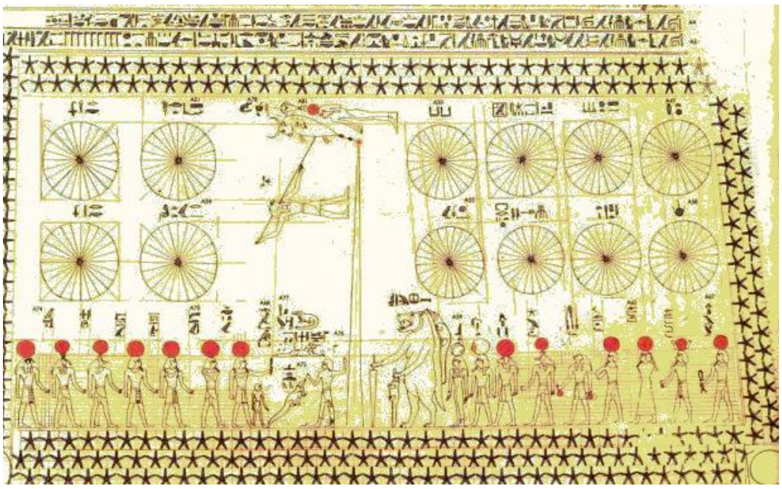
Ancient Temple is a more fitting classification, a place of astrological, spiritual, religious and ceremonial importance, much as present day cathedrals are places of prestige and worship where dignitaries may be laid to rest. When Newgrange was built the entrance and the internal passage were astrologically aligned to the winter solstice, so, on the shortest day of the year, the sun shines directly through the entrance down the full length of the passage to light up the interior of the tomb.





Maeshowe is a Neolithic chambered cairn and passage grave situated on the Main Island of Orkney in Scotland. It was probably built in around **2800 BC.** Its entrance passageway is also astrologically aligned to the winter solstice.

Let us now look at a very brief history of Astronomy highlighting some of the major events.



This is an astronomical Chart from Senemut's tomb, 18th dynasty. **Senenmut** was an ancient Egyptian architect and government official. The earliest known star map in Egypt is found as a main part of a decor in the Tomb of Senemut. The astronomical ceiling in Senenmut's tomb is divided into two sections representing the northern and the southern skies. This indicates other dimension of his career, suggesting that he was an ancient astronomer as well.

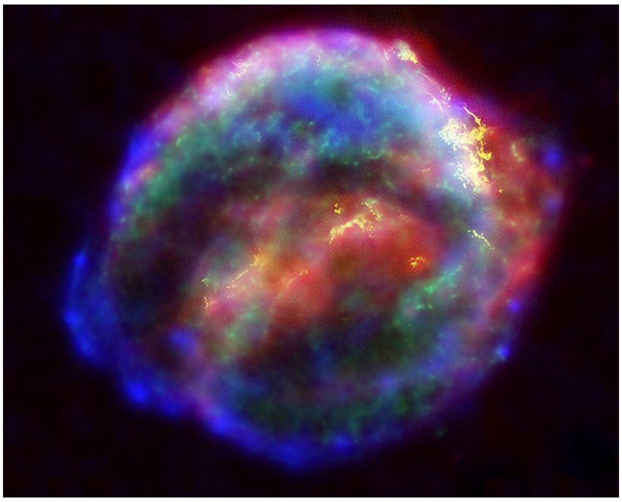
From **2000BC** to **500BC** the Babylonians keep astronomical records and in 500 BC they identified the Metonic or lunisolar cycle. The Lunisolar cycle relates to both the Sun and the Moon, especially to the gravitational pull of both the Sun and the Moon.

400BC Greeks begin to develop models of Earth and sky, spherical Earth, lunar phases, geocentric system of circular motion.

340-323BC Aristotle distinguishes between "terrestrial" and "celestial" phenomena, and Earth as the natural centre of the Universe.

1200AD -1500AD Aristotelian astronomy taught in universities and textbooks written.

Kepler's supernova or **Kepler's star** was a supernova that occurred in the Milky Way, in the constellation Ophiuchus **[o-fe-u-kus]** appearing in **1604,** it is the most recent supernova to have been unquestionably observed by the naked eye in our own galaxy, occurring no further than 20,000 light-years from Earth.

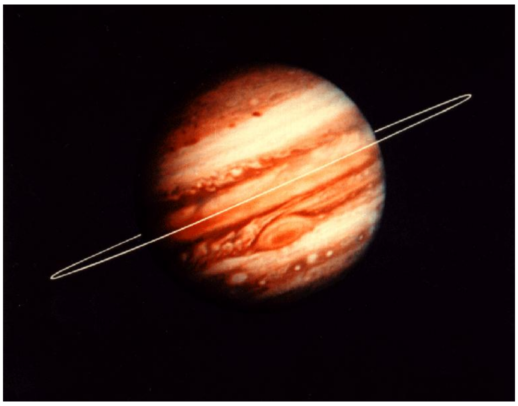


Kepler's Super Nova remnant.

Galileo Galilei.

Galileo who is considered the father of modern astronomy was born on February 15, 1564, in Pisa, Italy. He was a mathematics professor who made pioneering observations of nature with long-lasting implications for the study of physics.

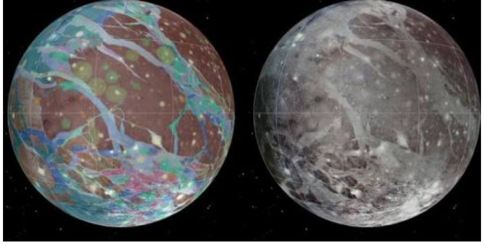
He also constructed a telescope and supported the Copernican theory, which supports a sun-centred solar system.



In his observations he discovers the moons or satellites of Jupiter *(left)*. **Jupiter** is the fifth planet from the Sun and the largest planet in the Solar System. It is a gas giant with mass one-thousandth of that of the Sun but is two and a half times the mass of all the other planets in the Solar System combined. Jupiter is classified as a gas giant along with Saturn, Uranus and Neptune. Together, these four planets are sometimes referred to as the Jovian or outer planets. The planet was known by astronomers of ancient times, and was associated with the mythology and religious beliefs of many cultures. The Romans named the planet after the Roman god Jupiter.

When viewed from Earth, Jupiter can reach an apparent magnitude of −2.94, bright enough to cast shadows, and making it on average the third-brightest object in the night sky after the Moon and Venus. Mars can briefly match Jupiter's brightness at certain points in its orbit.

Our solar system's largest moon, **Ganymede of Jupiter,** has never been completely mapped — until now. Scientists led by Wheaton College's Geoffrey Collins combined data from NASA's Voyager 1, 2 and Galileo spacecrafts to create this, the first global geologic map of icy Ganymede, Jupiter's seventh moon. This map *(right)* is helping planetary scientists to decipher the evolution of this icy world and will aid in upcoming spacecraft observations.



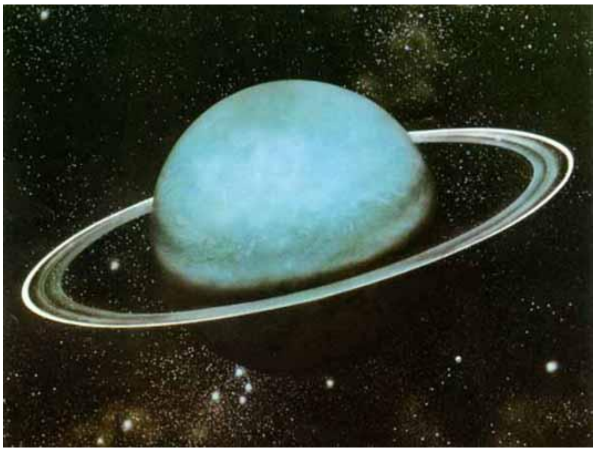
Galileo was accused twice of heresy by the church for his beliefs, he wrote books on his ideas. He died in Arcetri, Italy, on January 8, 1642.

In **1667 Kepler** improves telescope design and the Paris Observatory is established. The Royal Observatory, home of Greenwich Mean Time and the Prime Meridian line, is one of the most important historic scientific sites in the world. It was founded by Charles II in **1675** and is, by International decree, the official starting point for each new day, year and millennium at the stroke of midnight GMT as measured from the Prime Meridian.

The Observatory is now part of the National Maritime Museum and is one of the most famous features of Maritime Greenwich and since **1997** it has been a UNESCO World Heritage Site. The Observatory galleries unravel the extraordinary phenomena of time, space and astronomy while the planetarium lets visitors explore the wonders of the heavens.

Between **1700 and 1800**. The rapid development of astronomical instrumentation: reflecting telescopes, improved eyepieces. Numerous star catalogues. First studies of 'nebulae' by Herschel and Messier. First attempts to understand the Galaxy. Many detailed Newtonian calculations of planetary and lunar orbits.

Bradley, stellar aberration. Wright's early speculations on the structure of the Galaxy. Dolland creates the achromatic lens. Halley's comet duly returns in 1759, the Transit of Venus in 1761, Michell recognises existence of binary stars and stellar clusters. 1781 Messier's catalogue of "things that aren't comets".



In 1781 Herschel discovers Uranus.

Uranus is the seventh planet from the Sun. It has the third-largest planetary radius and fourth-largest planetary mass in the Solar System. Uranus is similar in composition to Neptune, and both are of different chemical composition than the larger gas giants Jupiter and Saturn. For this reason, astronomers sometimes place them in a separate category called "ice giants". Uranus's atmosphere, although similar to Jupiter's and Saturn's in its primary composition of hydrogen and helium, contains more "ices" such as water, ammonia, and methane, along with traces of hydrocarbons. It is the coldest planetary atmosphere in the Solar System, with a minimum temperature of 49 K (−224.2 °C), and has a complex, layered cloud structure, with water thought to make up the lowest clouds, and methane the uppermost layer of clouds. In contrast, the interior of Uranus is mainly composed of ices and rock.

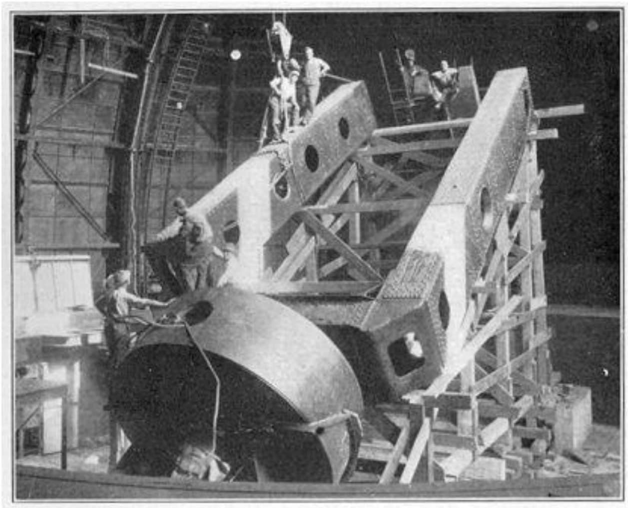
The period from **1800 to 1900** saw major technological developments in telescope making by Joseph von Fraunhofer, he was a German optician. He is known for the discovery of the dark absorption lines known as Fraunhofer lines in the Sun's spectrum, and for making excellent optical glass and achromatic telescope objectives. Also between 1800 and 1900 saw the introduction of the science to determine the chemical composition of substances and the physical properties of molecules, ions, and atoms and the introduction of photography which was the birth of modern observational astronomy.

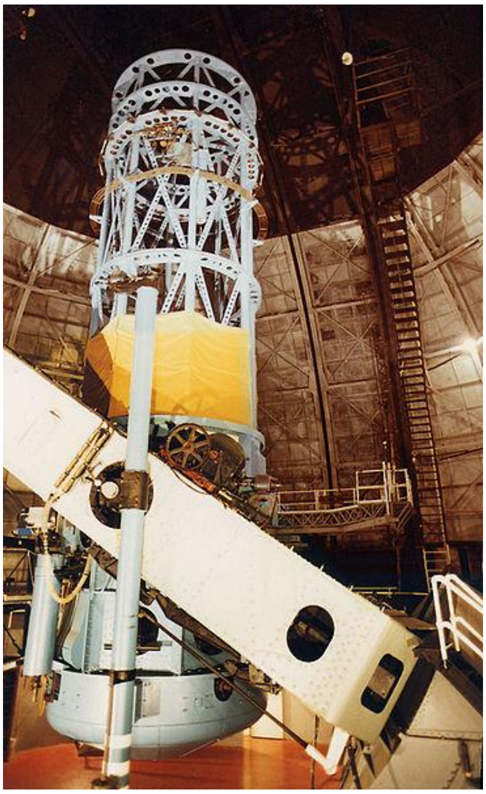
Joseph von Fraunhofer.

From 1900 the advance has been spectacular including the **Mt Wilson Observatory.** The Mt. Wilson Observatory is an astronomical observatory in Los Angeles County, California. It is located on Mount Wilson on a 5,715 foot peak in the San Gabriel Mountains near Pasadena, north-east of Los Angeles. The observatory contains two historically important telescopes: the 60-inch Hale Telescope built in 1908 and the 100-inch Hooker telescope, which was the largest telescope in the world from its completion in 1917 until the 200-inch Hale telescope at Palomar Observatory was built in 1948.

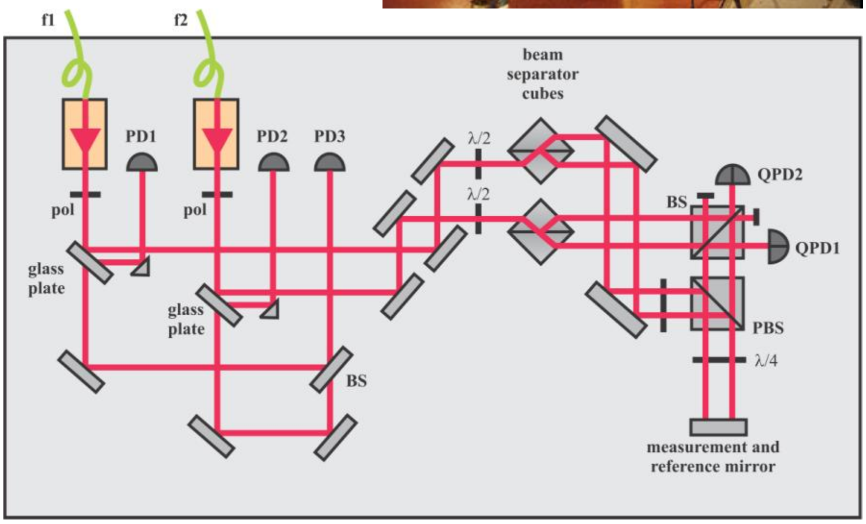
Once the 60-inch telescope project was well underway, Hale immediately set about creating a larger telescope. John D. Hooker provided crucial funding for it, along with Carnegie. The Saint-Gobain factory was again chosen to cast a blank for the mirror in 1906, which it completed in 1908.

The Blank started with over two tons of fused glass which was melted in a furnace into one piece. The blank once melted into one piece took over a year to cool without cracking. After considerable trouble over the blank and potential replacements, the 100-inch telescope was completed and saw "first light" on November 2, 1917.

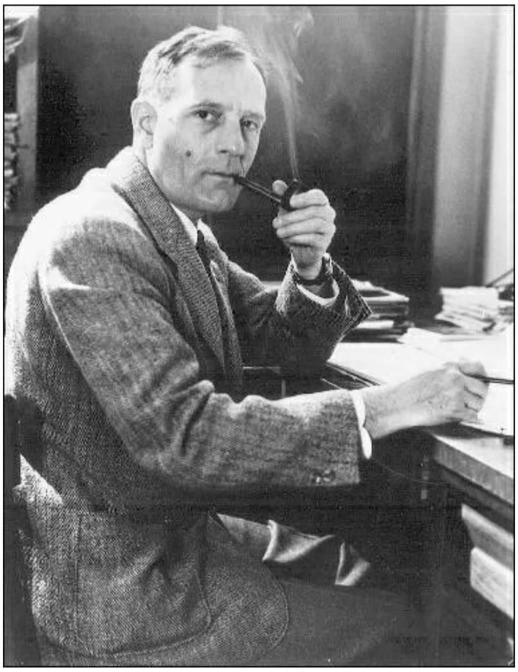




In **1919** the Hooker telescope was equipped with a special attachment, an optical astronomical interferometer developed by Albert Michelson, much larger than the one he had used to measure . Jupiter's satellites. Michelson was able to use the equipment to determine the precise diameter of stars, and this was the first time the size of a star had ever been measured, Henry Norris Russel developed his star classification system based on observations using the Hooker Telescope.



A schematic of the interferometer.



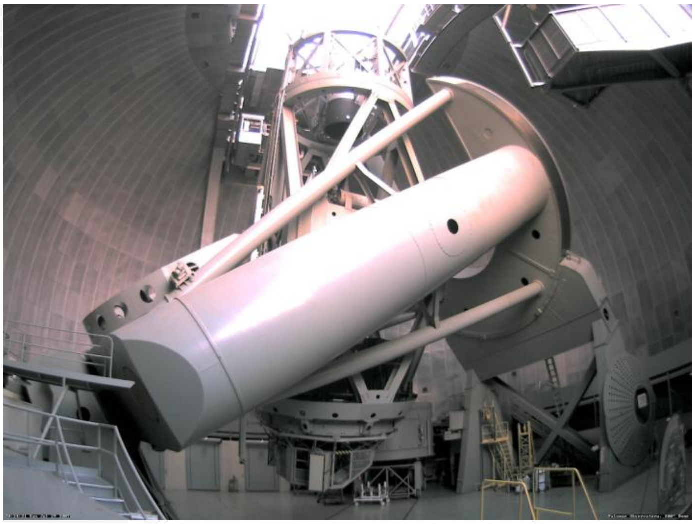
Edwin Hubble performed his critical calculations from work on the 100-inch telescope. He determined that some nebulae were actually galaxies outside our Milky Way. Hubble, assisted by Milton Humason, discovered the presence of the redshift that indicates the universe is expanding.

Edwin Hubble

1932 Jansky, invents radio astronomy. **1939 Bethe**, discovers the theory of hydrogen fusion and in **1946** the V2 rockets are used for astronomy.

The Hooker telescope's reign of three decades as the largest telescope came to an end when the Caltech-Carnegie consortium completed its 200-inch telescope in 1948 at Palomar Observatory, 90 miles south, in San Diego County, California.

The Hale Telescope.



The Palomar Observatory houses the Hale 200-inch telescope as well as the 48-inch Schmidt. It is a world-class center of astronomical research that is owned and operated by the California Institute of Technology.

The observatory is home to five telescopes that are nightly used for a wide variety of astronomical research programs.

In 1900's Eddington measures bending of light.
Also in the 1900's the Hubble telescope is completed.

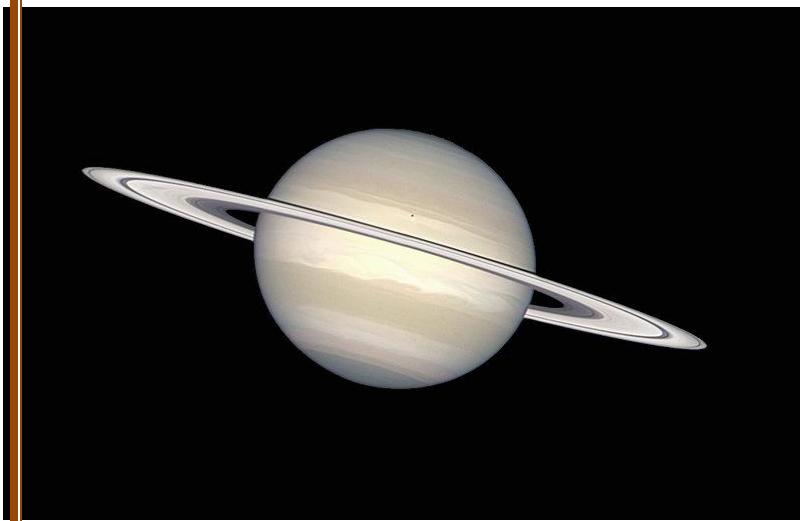
When Galileo first turned a spyglass to the heavens in 1610, he had trouble making out the rings of Saturn that are visible today by using an inexpensive home telescope. Advances in optics improved scientists' views of the planets, stars, and distant galaxies, but Earth's atmosphere still blocked much of the light for observers on the ground. Larger telescopes were, and still are, placed on high mountains, where the thinner atmospheres allow clearer pictures.

In **1923**, German scientist Herman Oberth first suggested that a telescope could be launched into orbit to help overcome the distortions caused by the atmosphere. As rocket launchings became more commonplace, the idea became feasible, and in 1969, approval was given for the launch of a Large Space Telescope. But its development took longer than preparing for a trip to the moon.

The Hubble Space Telescope.

In **1975**, the European Space Agency began work with NASA on the plan that would eventually become Hubble. Congress approved funding for the telescope in **1977**. The birth of the reusable Space Shuttle provided a new mechanism for delivering such a telescope into space.

The Large Space Telescope was renamed the Hubble Space Telescope in honour of Edwin Hubble. The world's first space telescope was then launched on April 24, 1990. The effort cost $1.5 billion, but there were ongoing costs, both expected and unexpected.



This is the image of **Saturn** in natural colours captured by the Hubble Telescope.

Saturn is the farthest planet from Earth visible to the naked human eye. The yellow and gold bands seen in Saturn's atmosphere are the result of super-fast winds in the upper atmosphere, which can reach up to 1,100 mph (1,800 kph) around its equator, combined with heat rising from the planet's interior.

Saturn spins faster than any other planet except Jupiter, completing a rotation roughly every 10-and-a-half hours. This rapid spinning causes Saturn to bulge at its equator and flatten at its poles — the planet is 8,000 miles (13,000 km) wider at its equator than between the poles.

Scientists have chosen the top ten photos taken by Hubble.

Tenth Place: - The Trifid Nebula. A 'stellar nursery', 9,000 light years from here, it is where new stars are being born.

Ninth Place: - The glowering eyes from 114 million light years away are the swirling cores of two merging galaxies called NGC 2207 and IC 2163 in the distant Canis Major constellation

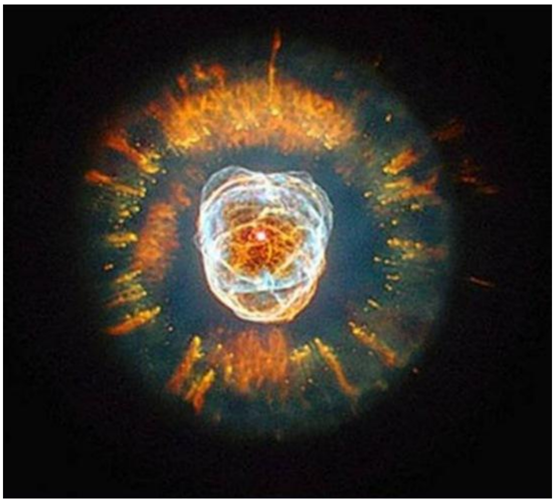
Eighth Place: - Starry Night, so named because it reminded astronomers of the Van Gogh painting. It is a halo of light around a star in the Milky Way

Seventh Place: - The Perfect Storm, a small region in the Swan Nebula, 5,500 light years away, described as 'a bubbly ocean of hydrogen and small amounts of oxygen, sulphur and other elements'.

In sixth place is the Cone Nebula. The part pictured here is 2.5 light years in length (the equivalent of 23 million return trips to the Moon).

Fifth Place: - The Hourglass Nebula, 8,000 light years away, has a pinched-in-the-middle look because the winds that shape it are weaker at the centre.

At fourth place is the Cat's Eye Nebula



In third place is Nebula NGC 2392, called Eskimo because it looks like a face surrounded by a furry hood. The hood is, in fact, a ring of comet-shaped objects flying away from a dying star. Eskimo is 5,000 light years from Earth.

Second Place: - The Ant Nebula, a cloud of dust and gas whose technical name is Mz3, resembles an ant when observed using ground-based telescopes. The nebula lies within our galaxy between 3,000 and 6,000 light years from Earth

First Place: - The Sombrero Galaxy - 28 million light years from Earth - was voted best picture taken by the Hubble telescope.

The dimensions of the galaxy, officially called M104, are as spectacular as its appearance. It has 800 billion suns and is 50,000 light years across.

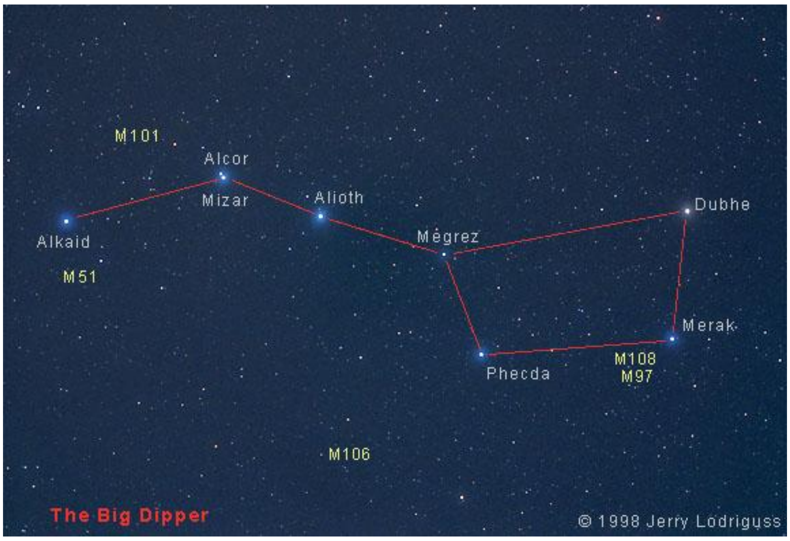
A light year is 9,461,000,000,000 kilometres (9 Trillion 461 billion.)

What is happening today?

To answer this we turn to an article written by Trent Gillis entitled:

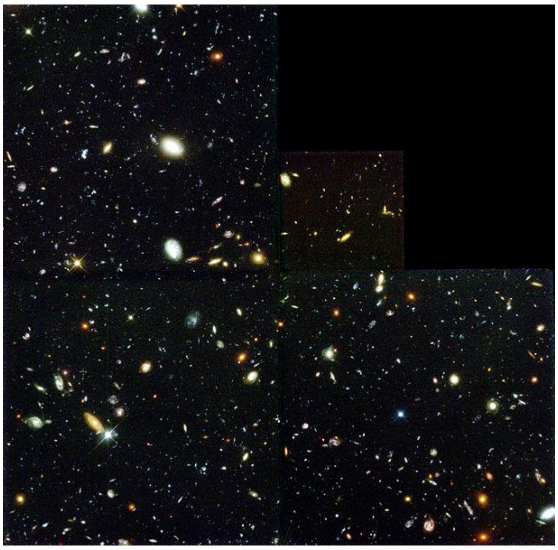
Deep Astronomy.

Astronomers in 1995 attempted to do something extraordinary, they pointed the Hubble Space Telescope into a part of the sky that seemed to be utterly empty, a patch totally devoid of any planets, stars and galaxies. This area was in the constellation **Ursa Major** close to the **Big Dipper.**



The Big Dipper is also known as the Plough. It is an asterism or cluster of stars smaller than a constellation. It consists of seven stars that has been recognised as a distinct grouping in many cultures from time immemorial.

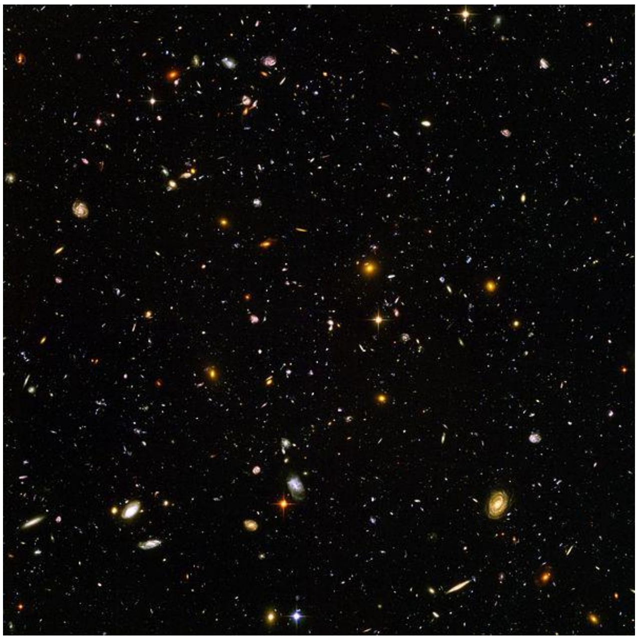
The patch of sky that they were interested in was no bigger than a grain of sand held at arm's length. This was a some-what risky move by the scientist, as the observing time on this telescope is in very high demand and some questioned would it be wasted trying to look at nothing. There was a real risk that the images being returned would be as black as the space at which it was pointed. Nevertheless they opened the telescope and slowly over the course of ten full days, photons that had been travelling over 13 billion years, finally ended their journey on the detector of humanities most powerful telescope. Using 342 separate exposures taken by the Space Telescope's Wide Field and Planetary Camera 2. Their feeble signals collected almost one by one.



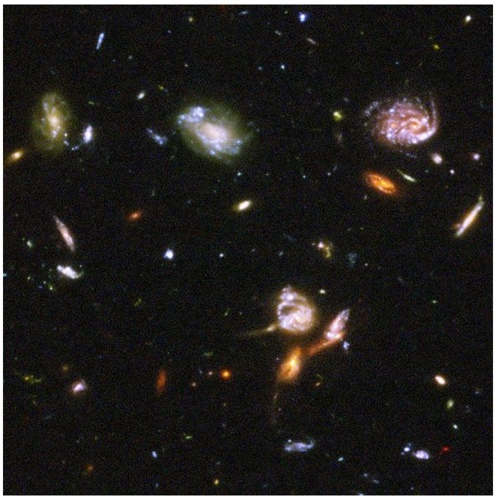
When the telescope was finally closed and the images processed, the light from over three thousand galaxies had covered the detector, producing one of the most profound and humbling discoveries in all human history. Every single spot, smear and dot was an entire galaxy and each one containing hundreds of billions of stars.

Dramatic improvements were made to Hubble's imaging capabilities so after corrective optics were installed it encouraged scientists to attempt to obtain very deep images of distant galaxies as shown above.

Later in **2004** they did it again, this time, pointing the telescope toward an area near the constellation **Orion**.

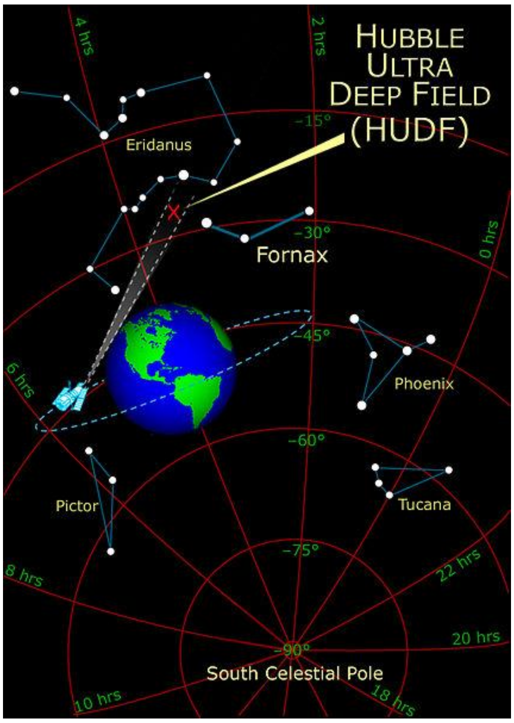


They opened the shutter and over 11 days and over 400 complete orbits around the earth, using detectors with increased sensitivity and filters that allow more light through than ever before, over 10,000 galaxies appeared in what has become known as **the Ultra Deep Field**, an image that represents the farthest we have ever seen in the Universe. The photons that left when the Universe was only 500 million years old and 13 billion years later they end their long journey as a small blip on a telescope CCD.

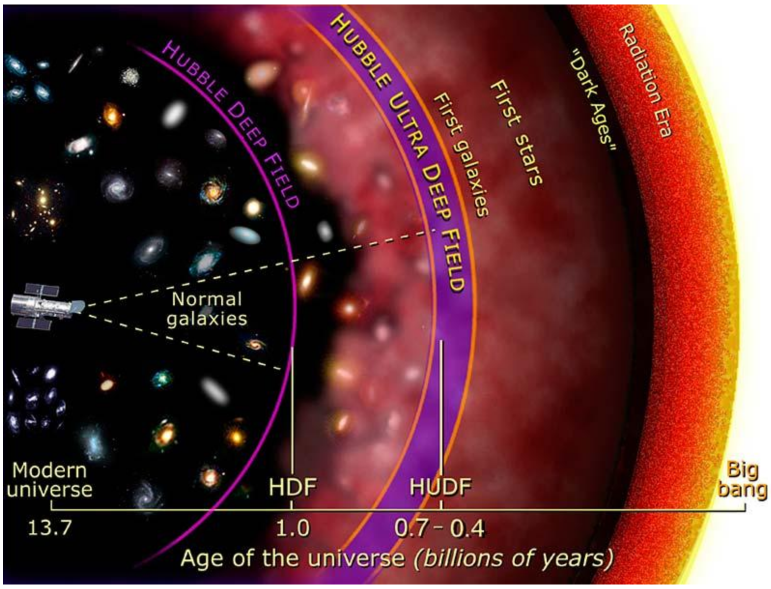


We zoom in on the upper middle-left part of the Hubble Ultra-deep Field.

The star nearest the centre of the field is USNO A2 which is a Spiral Galaxy.



This is a diagram showing the relationship between the Hubble telescope and the Ultra Deep Field to Earth.



The **Hubble extreme Deep Field** (XDF) is an image of a small part of space in the centre of the Hubble Ultra Deep Field within the constellation Fornax, showing the deepest optical view in space.

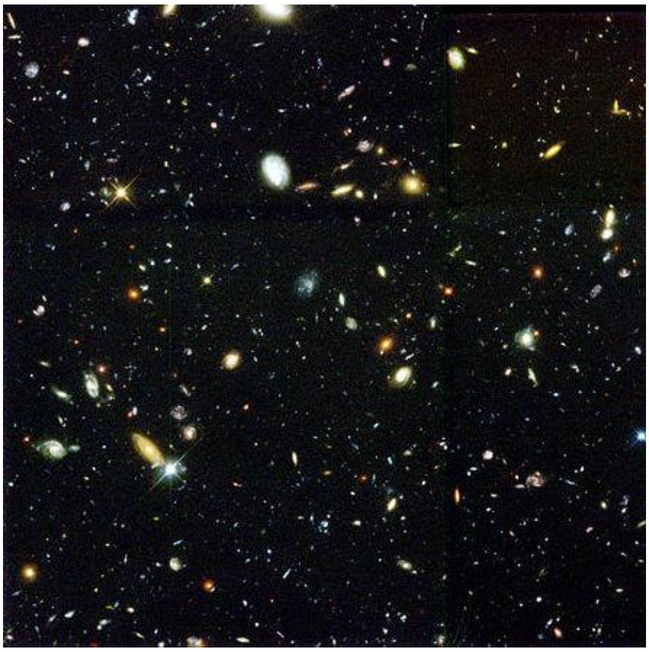
Released on September 25, 2012, it took 10 years to compile the images and shows galaxies from 13.2 billion years ago. The exposure time was two million seconds, or approximately 23 days. The faintest galaxies are one ten-billionth the brightness of what the human eye can see. The red galaxies are the remnants of galaxies after major collisions during their elderly years. Many of the smaller galaxies are very young galaxies that eventually became the major galaxies, like the Milky Way and other galaxies in our galactic neighbourhood. The Hubble extreme Deep Field, or XDF, adds another 5,500 galaxies to Hubble's 2003 and 2004 view into a tiny patch of the farthest universe.

Space. Patches of complete black, void of light. We see nothing. And yet, our species peers more deeply and seeks for what it cannot see. Our curiosity is a springboard, a launching pad for that leap of faith into the unknown.

So, what did we do?

We committed, and we pointed the Hubble Space Telescope at one of those dark patches in 1996. The result: one of the most important images ever taken. Where we saw nothing, there were galaxies — more than 3,000 of them. And when we looked more deeply, our field of view expanded to more than 100 billion galaxies.

Our vision of ourselves is forever changed.



Today Astronomy is not just star gazing, there is serious study continuing, trying to understand what our universe is made of. Albert Einstein was the first person to realize that empty space is not nothing.

In the early 1990s, one thing was fairly certain about the expansion of the Universe. It might have enough energy density to stop its expansion and recollapse, it might have so little energy density that it would never stop expanding, but gravity was certain to slow the expansion as time went on. Granted, the slowing had not been observed, but, theoretically, the Universe had to slow. The Universe is full of matter and the attractive force of gravity pulls all matter together. Then came 1998 and the Hubble Space Telescope (HST) observations of very distant supernovae that showed that, a long time ago, the Universe was actually expanding more slowly than it is today. So the expansion of the Universe has not been slowing due to gravity, as everyone thought, it has been accelerating. No one expected this, no one knew how to explain it. But something was causing it.

Eventually theorists came up with three sorts of explanations. Maybe it was a result of a long-discarded version of Einstein's theory of gravity, one that contained what was called a "cosmological constant." Maybe there was some strange kind of energy-fluid that filled space. Maybe there is something wrong with Einstein's theory of gravity and a new theory could include some kind of field that creates this cosmic acceleration. Theorists still don't know what the correct explanation is, but they have given the solution a name. It is called **dark energy**.

What Is Dark Energy?

More is unknown than is known. We know how much dark energy there is because we know how it affects the Universe's expansion. Other than that, it is a complete mystery. But it is an important mystery. It turns out that roughly 68% of the Universe is dark energy. Dark matter makes up about 27%. The rest - everything on Earth, everything ever observed with all of our instruments, all normal matter - adds up to less than 5% of the Universe.

Come to think of it, maybe it shouldn't be called "normal" matter at all, since it is such a small fraction of the Universe. One explanation for dark energy is that it is a property of space. Space has amazing properties, many of which are just beginning to be understood. The first property that Einstein discovered is that it is possible for more space to come into existence. Then one version of Einstein's gravity theory, the version that contains a cosmological constant, makes a second prediction: "empty space" can possess its own energy. Because this energy is a property of space itself, it would not be diluted as space expands. As more space comes into existence, more of this energy-of-space would appear. As a result, this form of energy would cause the Universe to expand faster and faster. Unfortunately, no one understands why the cosmological constant should even be there, much less why it would have exactly the right value to cause the observed acceleration of the Universe.

Scientist turned to the Hubble Space Telescope for some answers. The initial observations, made in 2007 were so unusual that astronomers shrugged them off as unreal, due to poor data. However, new results from Hubble confirmed that dark matter and galaxies parted ways in the gigantic merging galaxy cluster called Abell 520. located 2.4 billion light-years away.

This image shows the distribution of dark matter (in blue), galaxies, and hot gas in the core of the merging galaxy cluster Abell 520. The result could present a challenge to basic theories of dark matter.

Another explanation for how space acquires energy comes from the quantum theory of matter. In this theory, "empty space" is actually full of temporary ("virtual") particles that continually form and then disappear. But when physicists tried to calculate how much energy this would give empty space, the answer came out wrong - wrong by a lot. The number came out 10^{120} times too big. That's a 1 with 120 zeros after it. It's hard to get an answer that bad.

Another explanation for dark energy is that it is a new kind of dynamical energy fluid or field, something that fills all of space but something whose effect on the expansion of the Universe is the opposite of that of matter and normal energy. Some theorists have named this "quintessence," after the fifth element of the Greek philosophers. But, if quintessence is the answer, we still don't know what it is like, what it interacts with, or why it exists.

A last possibility is that Einstein's theory of gravity is not correct. That would not only affect the expansion of the Universe, but it would also affect the way that normal matter in galaxies and clusters of galaxies behaved. This fact would provide a way to decide if the solution to the dark energy problem is a new gravity theory or not: we could observe how galaxies come together in clusters. But if it does turn out that a new theory of gravity is needed, what kind of theory would it be? How could it correctly describe the motion of the bodies in the Solar System, as Einstein's theory is known to do, and still give us the different prediction for the Universe that we need? There are candidate theories, but none are compelling. So the mystery continues.

The thing that is needed to decide between dark energy possibilities - a property of space, a new dynamic fluid, or a new theory of gravity - is more data, better data.

What Is Dark Matter?

Abell 2744: Pandora's Cluster Revealed.

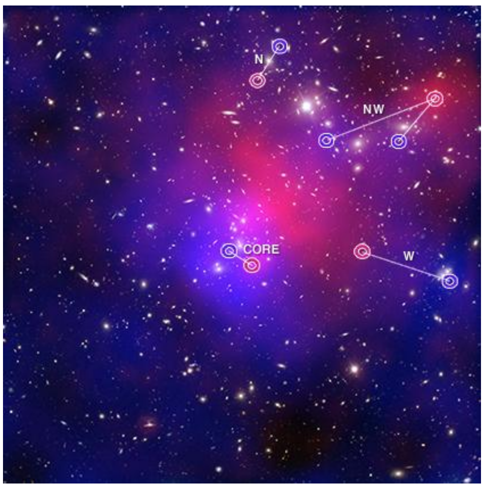
One of the most complicated and dramatic collisions between galaxy clusters ever seen is captured in this new composite image of Abell 2744. The blue shows a map of the total mass concentration (mostly dark matter).

By fitting a theoretical model of the composition of the Universe to the combined set of cosmological observations, scientists have come up with the composition that we described above, ~68% dark energy, ~27% dark matter, ~5% normal matter.

What is dark matter? We are much more certain what dark matter is not than we are what it is. First, it is dark, meaning that it is not in the form of stars and planets that we see. Observations show that there is far too little visible matter in the Universe to make up the 27% required by the observations.

Second, it is not in the form of dark clouds of normal matter, matter made up of particles called baryons. We know this because we would be able to detect baryonic clouds by their absorption of radiation passing through them. Third, dark matter is not antimatter, because we do not see the unique gamma rays that are produced when antimatter annihilates with matter. Finally, we can rule out large galaxy-sized black holes on the basis of how many gravitational lenses we see. High concentrations of matter bend light passing near them from objects further away, but we do not see enough lensing events to suggest that such objects to make up the required 25% dark matter contribution.

However, at this point, there are still a few dark matter possibilities that are viable. Baryonic matter could still make up the dark matter if it were all tied up in brown dwarfs or in small, dense chunks of heavy elements. These possibilities are known as massive compact halo objects, But the most common view is that dark matter is not baryonic at all, but that it is made up of other, more exotic particles like axions, hypothetical subatomic particles or weakly interacting massive particles.



Abell 2744 .

The authors of this study retraced the details of the collision, and deduce that at least four different galaxy clusters coming from a variety of directions were involved. To understand this history, it was crucial to map the positions of all three types of matter in Abell 2744. Although the galaxies are bright, they make up less than 5% of the mass in Abell 2744. The rest is hot gas (around 20%) visible only in X-rays, and dark matter (around 75%), which is completely invisible.

Dark matter is particularly elusive as it does not emit, absorb or reflect light, but only makes itself apparent through its gravitational attraction. To pinpoint the location of this mysterious substance the team used a phenomenon known as gravitational lensing. This is the bending of light rays from distant galaxies as they pass through the gravitational field present in the cluster. The result is a series of telltale distortions in the images of galaxies in the background of optical observations. By carefully plotting the way that these images are distorted, a map is constructed of where the mass -- and hence the dark matter -- actually lies (shown in blue).

Galaxy clusters are the largest gravitationally bound objects in the Universe and have become powerful tools in cosmology studies. Further studies of Abell 2744 may provide a deeper understanding of the way that these important objects grow and provide new insight into the properties of dark matter.

Source: A paper by NASA Science on Dark Matter and Dark Energy.

Many experiments to detect proposed dark matter particles through non-gravitational means are under way.

The first to suggest the existence of dark matter (using stellar velocities) was Dutch astronomer Jacobus Kapteyn in 1922. Fellow Dutchman and radio astronomy pioneer Jan Oort also hypothesized the existence of dark matter in 1932. Oort was studying stellar motions in the local galactic neighbourhood and found that the mass in the galactic plane must be greater than what was observed, but this measurement was later determined to be erroneous.

In 1933, Swiss astrophysicist Fritz Zwicky, who studied galactic clusters while working at the California Institute of Technology, made a similar inference. Zwicky applied the virial theorem to the Coma galaxy cluster and obtained evidence of unseen mass that he called *dunkle Materie* 'dark matter'. Zwicky estimated its mass based on the motions of galaxies near its edge and compared that to an estimate based on its brightness and number of galaxies. He estimated that the cluster had about 400 times more mass than was visually observable. The gravity effect of the visible galaxies was far too small for such fast orbits, thus mass must be hidden from view. Based on these conclusions, Zwicky inferred that some unseen matter provided the mass and associated gravitation attraction to hold the cluster together. This was the first formal inference about the existence of dark matter. Zwicky's estimates were off by more than an order of magnitude, mainly due to an obsolete value of the Hubble constant; the same calculation today shows a smaller fraction, using greater values for luminous mass. However, Zwicky did correctly infer that the bulk of the matter was dark.

The first robust indications that the mass to light ratio was anything other than unity came from measurements of galaxy rotation curves. In 1939, Horace W. Babcock reported the rotation curve for the Andromeda nebula, which suggested that the mass-to-luminosity ratio increases radially. He attributed it to either light absorption within the galaxy or modified dynamics in the outer portions of the spiral and not to missing matter.

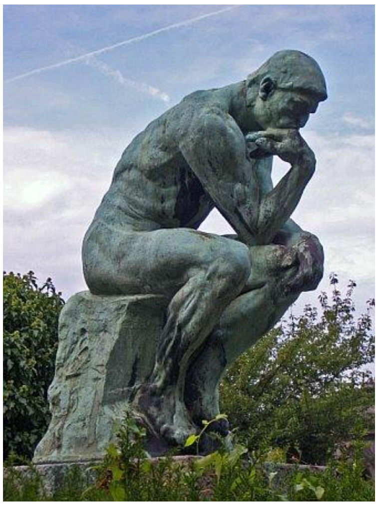
Vera Rubin and Kent Ford in the 1960s–1970s provided further strong evidence, also using galaxy rotation curves. Rubin worked with a new spectrograph to measure the velocity curve of edge-on spiral galaxies with greater accuracy. This result was independently confirmed in 1978. An influential paper presented Rubin's results in 1980. Rubin found that most galaxies must contain about six times as much dark as visible mass; thus, by around 1980 the apparent need for dark matter was widely recognized as a major unsolved problem in astronomy.

A stream of independent observations in the 1980s indicated its presence, including gravitational lensing of background objects by galaxy clusters, the temperature distribution of hot gas in galaxies and clusters, and the pattern of anisotropies in the cosmic microwave background. According to consensus among cosmologists, dark matter is composed primarily of a not yet characterized type of subatomic particle. The search for this particle, by a variety of means, is one of the major efforts in particle physics.

Much of the evidence comes from the motions of galaxies. Many of these appear to be fairly uniform, so by the virial theorem, the total kinetic energy should be half the galaxies' total gravitational binding energy. Observationally, the total kinetic energy is much greater. In particular, assuming the gravitational mass is due to only visible matter, stars far from the centre of galaxies have much higher velocities than predicted by the virial theorem. Galactic rotation curves, which illustrate the velocity of rotation versus the distance from the galactic centre, show the "excess" velocity. Dark matter is the most straightforward way of accounting for this discrepancy.

Ground-based interferometers[1] provided fluctuation measurements with higher accuracy, including the Very Small Array, the Degree Angular Scale Interferometer (DASI) and the Cosmic Background Imager (CBI). DASI first detected the CMB polarization, and CBI provided the first E-mode polarization spectrum with compelling evidence that it is out of phase with the T-mode spectrum. COBE's successor, the Wilkinson Microwave Anisotropy Probe (WMAP) provided the most detailed measurements of (large-scale) anisotropies in the CMB in 2003–2010. ESA's Planck spacecraft returned more detailed results in 2013-2015.

[1] See page 65 for a schematic of an Interferometer.



So we now come to the final question: what does astronomy mean to us today, as Freemasons and why should it be included in our list of studies.

Masonic teaching enthusiastically encourages us to contemplate and learn from the seven liberal arts and sciences. To expand our Masonic knowledge, as we have been instructed to do, we must make an effort to seek answers to life's great questions. Two of them are: "Who are we? and where did we come from?".

Over the last 20 centuries the Liberal Arts and Sciences have been an integral part of the progress of human knowledge and has become a superior foundation of the Craft and our place in history. No matter how advanced our society, we must never lose the need to reflect on life, to distinguish good from evil, justice from injustice, and what is noble and beautiful from what is useful.

The tradition of asking questions and reflecting on such issues has its origins in the classical thoughts of Greek philosophers, but it was during the age of enlightenment that the scope of the liberal arts expanded to comprise a broad range of humanities and sciences that provide the moral compass the Ancient Greeks sought and we still strive for today.

But where does the study of Astronomy fit into all this?

It was believed, and still is, that the learned man is a free man, liberated by the sciences, freed from the chains of ignorance and allows a person to govern his own life, "know thyself" being a critical part of the learning process.

To repeat the observation made at the beginning that: Astronomy is the art by which we can trace the great symmetry of the hand of the deity throughout the heavens. Astronomy helps us better understand God's creation and its mysteries.

Generally there are two recognised paths to approach God, one through praise, meditation and the reading of the sacred law, the second through direct observation of God's creation.

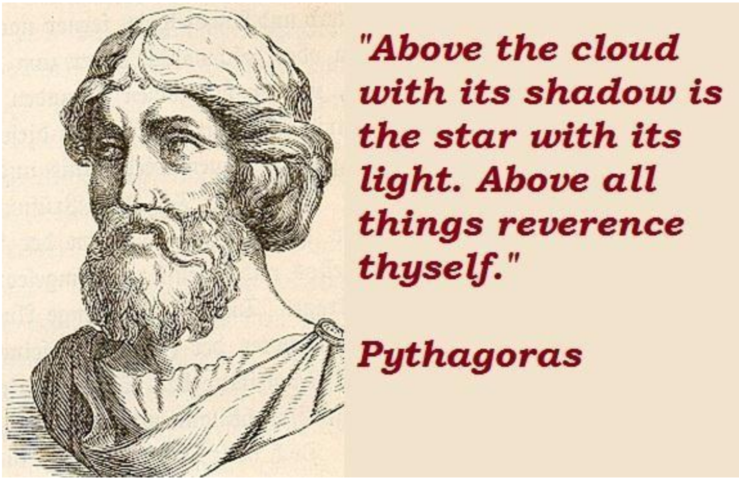
There are two titles in our ritual which are essentially at the heart of Freemasonry. The first is in the first Degree where we refer to the Great Architect of the Universe. The Lodge is opened in His Name and He is called upon for a blessing. Later the candidate kneels and in His presence takes a solemn obligation. In the second degree we refer to God the Grand Geometrician of the Universe.

In both these references, the key word is Universe as we recognise that He is not just the God of this world but the creator and master of the whole universe.

Then for us to discover God, The Grand Geometrician of the Universe, we must also discover the universe which He created, and to do this we must not only search the Volume of the Sacred Law for guidance and inspiration but we must also search the whole universe for His divine insights. In the first degree we are called upon to make a daily advancement in Masonic knowledge and in the second degree we are instructed to extend our researches into the hidden mysteries of nature and science.

To again quote the ritual: "The Universe is the Temple of the Deity whom we serve; Wisdom, Strength and Beauty are about His throne as pillars of His works, for His Wisdom is infinite, His strength omnipotent, and Beauty shines through the whole of the creation in symmetry and order. The Heavens He hath stretched forth as a canopy; the Earth He has planted as a footstool." Could we interpret these word in any other way than to urge us to know God's whole creation and our place in it.

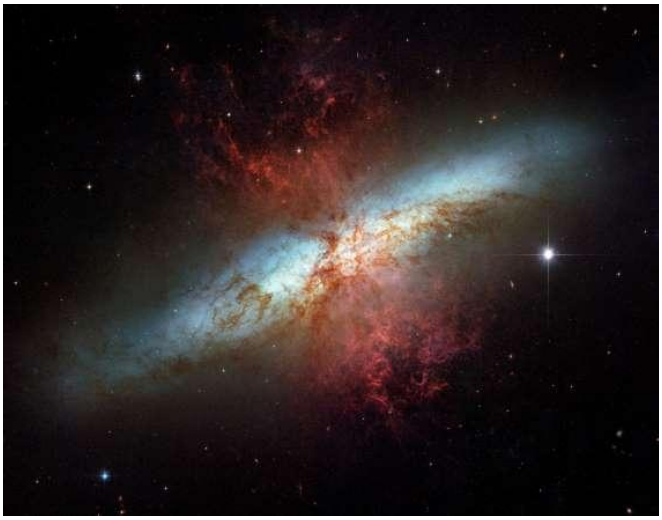
I hope that together, we have discovered first the incredible beauty of the universe and then its vast dimensions which to our finite mind is nearly incomprehensible and then to consider that we are a mere minuscule part of it, must surely beg the question, "what is our role in all of this?"
Are we mere observers or do we play a part, an integral part in the existence of the universe?

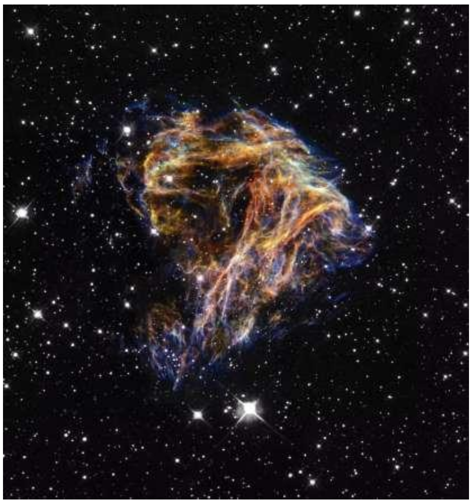


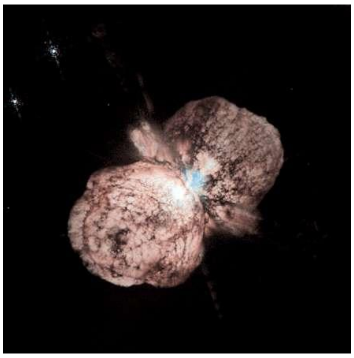
A photon: The quantum of electromagnetic energy, regarded as a discrete particle having zero mass, no electric charge, and n indefinitely long lifetime. A unit of retinal illumination, equal to the amount of light that reaches the retina through 1 square millimetre of pupil area from a surface having a brightness of 1 candela per square meter.

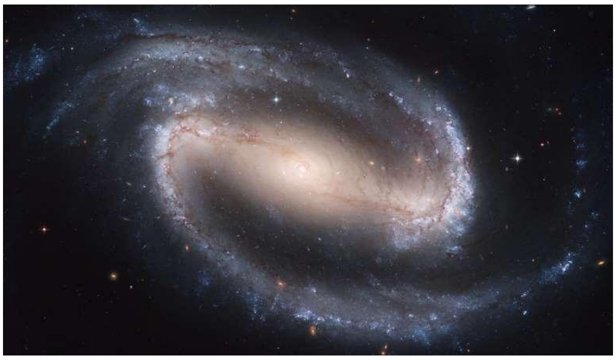
Light travels at a constant, finite speed of 186,000 mi/sec. A traveller, moving at the speed of light, would circum-navigate the equator approximately 7.5 times in one second. By comparison, a traveller in a jet aircraft, moving at a ground speed of 500 mph, would cross the continental U.S.A in 4 hours.

Some incredible photos of outer space.



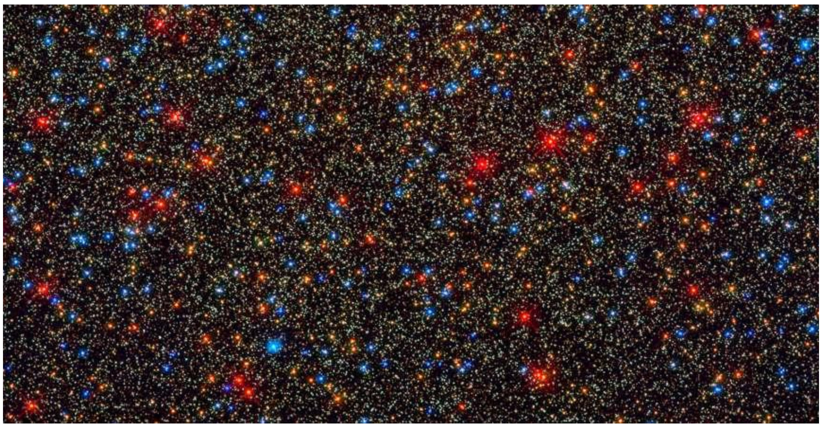
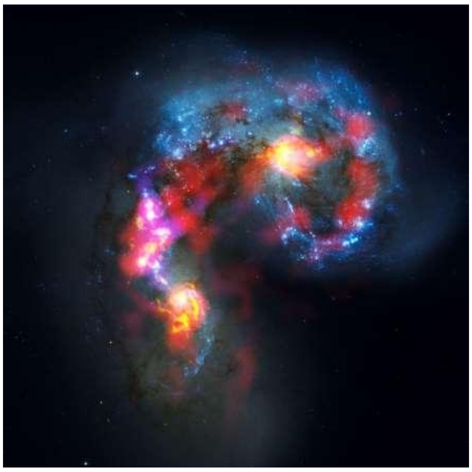


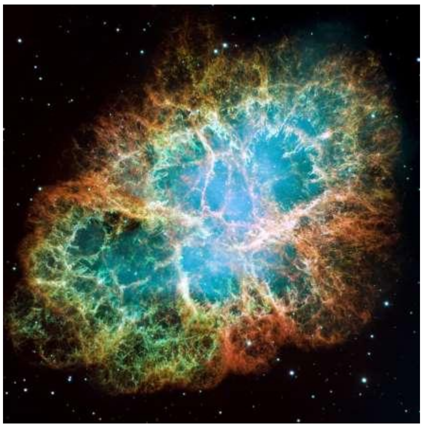


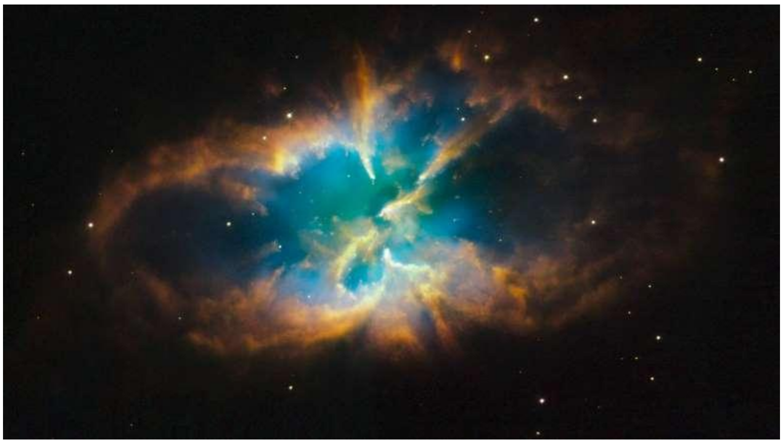


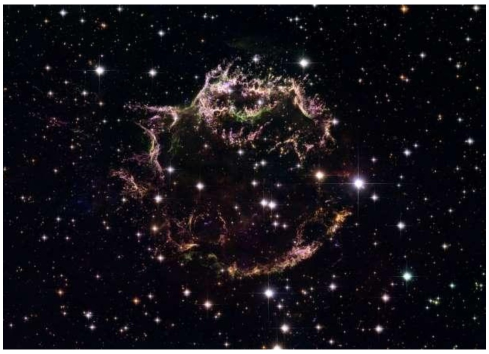


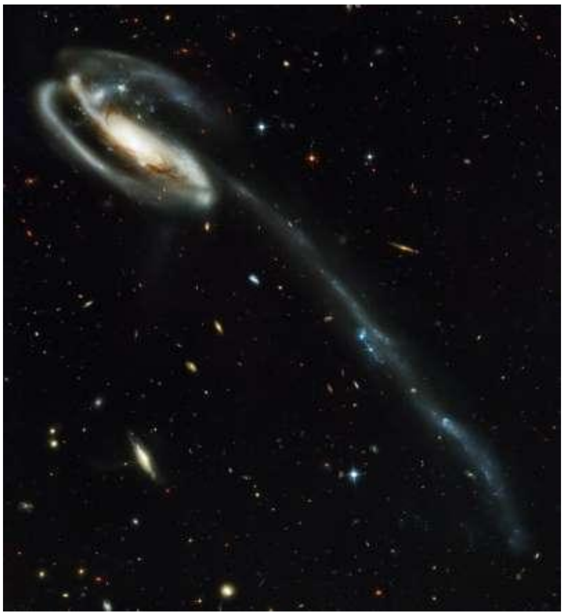


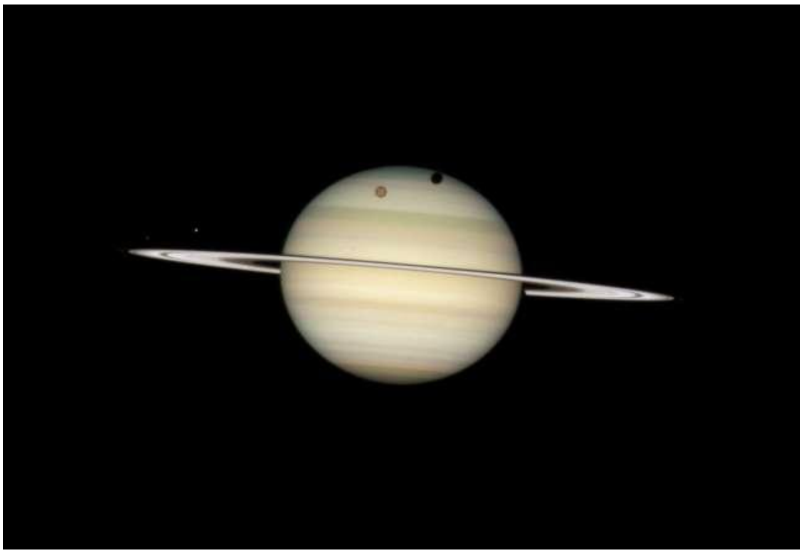



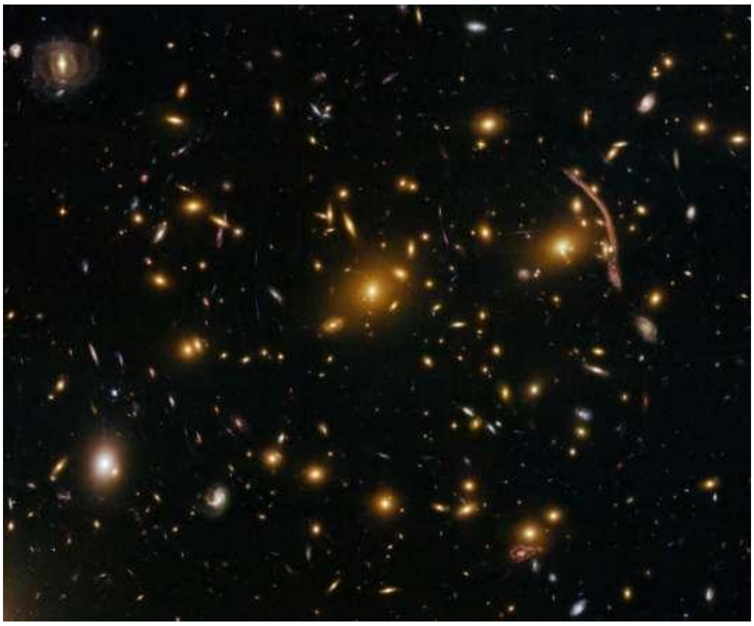



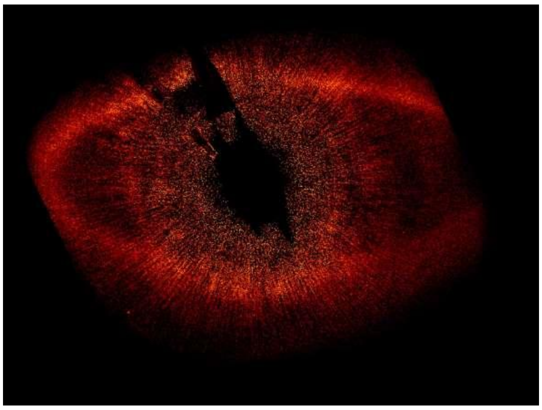


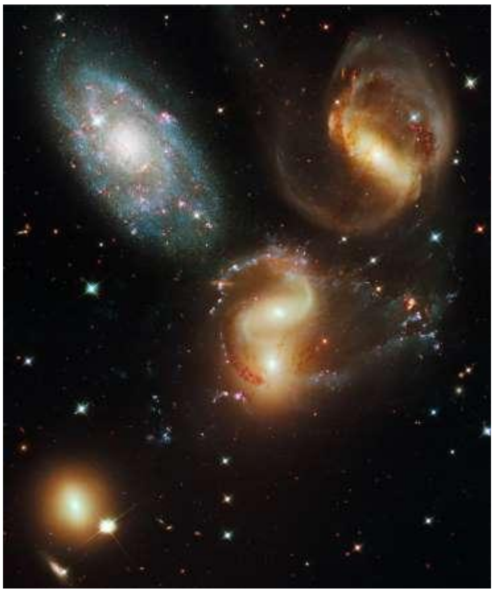


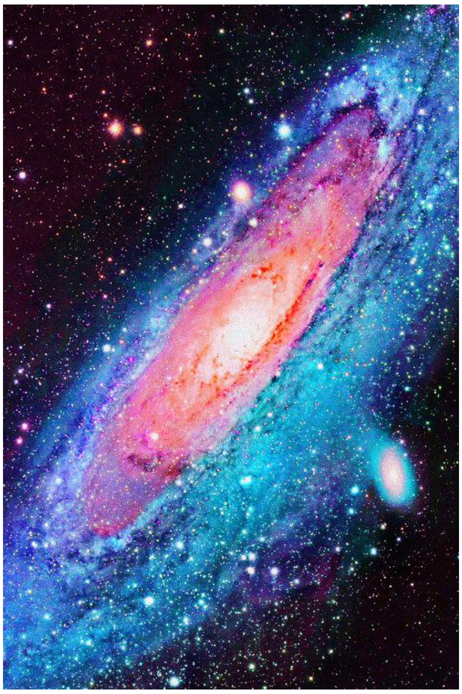












What is the future of the Seven Liberal Arts?

Understanding the origins and development of the seven Liberal Arts is one thing, while using this knowledge to our benefit and applying it to our lives is a different matter. Beyond our academic interest in the Liberal Arts, we should understand what they may have to offer to modern society. Our modern educational system is quite different from the classical and medieval systems that were once founded on the seven Liberal Arts. We may tend to think that this difference is the result of a natural evolution over time, and that our knowledge system must be far superior to that of medieval Europe, after all, we are much smarter than a medieval man, aren't we?

In absolute terms this proposition may be correct, as we do hold more information than a medieval man. But let's consider the same picture in relative terms – the amount of data projected at us in mere 24 hours is far superior to that received by a medieval man in his entire lifetime. Information about everything imaginable is received through our senses whatever we like it or not: from the news, text and images on our TV screens; paper publications, magazines and books around us; ads, signs and commercials that compete for our attention everywhere we look in our cities; the music in our cars, homes and personal devices; direct and indirect messages in our cinema and media; Internet and email communications, and so on. Our society has become extremely complex, and information of both good and questionable quality is so easily produced and disseminated that we get constantly bombarded by it.

The lecture presented by Dorothy Sayers at the University of Oxford in 1947 is relevant here: *"For we let our young men and women go out unarmed, in a day when armour was never so necessary. By teaching them all to read, we have left them at the mercy of the printed word. By the invention of the film and the radio, we have made certain that no aversion to reading shall secure them from the incessant battery of words, words, words. They do not know what the words mean; they do not know how to ward them off or blunt their edge or fling them back; they are a prey to words in their emotions instead of being the masters of them in their intellects.*

We who were scandalized in 1940 when men were sent to fight armoured tanks with rifles, are not scandalized when young men and women are sent into the world to fight massed propaganda with a smattering of "subjects"; and when whole classes and whole nations become hypnotized by the arts of the spell binder, we have the impudence to be astonished."

Miss Sayers' grim analysis of the state of education in Europe after WWII is nothing compared to the little understood impact of the information revolution (i.e. Internet, computers, online games, social networks, SMS text messages, iPods) on our youth.

In this essay ("The Lost Tools of Learning"), Miss Sayers suggests that we presently teach our children everything but how to learn. She proposes that we adopt a modified version of the medieval curriculum for new education methods. During World War II, she lived in Oxford, and was a member of the "Inklings", a known literary group that included Oxford poets, philosophers and authors such as C.S.Lewis ("The Chronicles of Narnia") and J.R.R. Tolkien ("The Lord of the Rings"). By nature and preference, she was a scholar and an expert on the Middle Ages. It is interesting how she is "*searching for an ancient treasure of knowledge"* that went missing, to save a corrupted society from itself.

Since 1947 the study of grammar has been greatly reduced in public education, and is usually associated with the very basics of the official language of the country we live in.

The study of dead languages is not even considered and usually laughed at as a joke, even though the basics of Latin could greatly facilitate and accelerate the learning of all Latin/Romance languages – allowing one to communicate with 800 million people in our planet who use dozens of these closely related languages. Just a rudimentary knowledge of Latin greatly reduces the effort of learning almost any other language, and it is the key to the vocabulary and structure of all the Germanic languages (such as English), as well as to the technical vocabulary of all the sciences and to the literature of the entire Mediterranean civilization, together with all its historical documents.

Rhetoric is usually limited to the writing of academic essays, and communicating meaningful ideas in an elegant manner is insufficiently emphasized on in schools.

Dialectic or Logic has become almost entirely detached from the rest of the curriculum, and is usually practiced irregularly and outside school hours.

The results of these phenomena are quite evident today in the communication skills of the average teenager, who goes home after school and is bombarded by sexually oriented pop music, watches “trash-TV shows” and plays commercial video games. A medieval student living in 14th century Europe could enter university at the age of 15 and would leave it knowing several languages and having the ability to name the stars, understand the arithmetic relation between the harmonics, read and write music, use plants to heal, know sacred texts and their meanings, and master several crafts. In spite of (and because of) the massive amount of information being created and projected at us today, one could argue that the old knowledge (and liberation) offered by learning the Liberal Arts has never been so missed as during the 21st century.

Applying the Seven Liberal Arts and Sciences to Freemasonry. The following are some passages from Masonic sources that the authors find relevant to this discussion.

Speculative Masonry continues homage to these seven liberal arts and sciences and, they are an important part of the second degree. So when the Fellow Craft is learning of these seven liberal arts and sciences there is a connection between the operative Masons of the Middle Ages and today. Those operative Masons held a laudable ambition to elevate the character of the craft above the ordinary standard of workmen.

- History of Freemasonry

After the industrial revolution in the late 18th and early 19th centuries our society has revolved around the values of individual drive, competitiveness and productivity (as they are associated with the generation of wealth.) Should these values have been so pervasive when Freemasonry evolved we would probably have witnessed a very different type of fraternity today. In fact, Masonic teachings – such as the study of the Liberal Arts – sometimes sound like distant echoes from the past, which insist in teaching that different values were once upheld by our ancestors – and are still important today. . These values create a tendency towards intellectual specialization - generalists are definitely not in vogue today. Our education curriculum is structured around very specialized fields – Biology, Mathematics, Physics, Law, etc; a modern-day Quadrivium that includes tens of disciplines. Thus, when told about the seven Liberal Arts and Sciences in our Masonic education, we naturally ask the question *“why these fields are more important than others?”* and *“what possible tangible and material benefit can I get from studying Rhetoric or Logic?”*

Taken by and large, the great difference rests in where the emphasis is placed within the two education systems. Modern education concentrates on teaching specialized subjects (skip the Trivium and jump to Quadrivium, accelerate specialization and increase productivity), leaving the method of thinking, arguing, and expressing one's conclusions to be picked up by the student as he goes along.

Medieval education concentrated on first forging the tools of learning, using whatever subject came handy as a piece of material on which to doodle until the use of the tool became second nature.

Are there any lessons that we can take from this?

Although it is undeniable that a complex and dynamic society demands specialists, after all, we still need neurosurgeons, astrophysicists and PhDs in applied economics, excessive specialization can also create isolation. We meet brothers in our lodges who do not work in the same profession as we do, and sometimes that makes initial contact difficult. Misunderstandings abound in modern communications, when face to face contact is a luxury we can hardly afford, how many times have we seen a well-intentioned email attempt to clarify a misunderstanding, only to make it worse? Most of us are specialists in some field of knowledge. However, being a specialist does not mean to have a closed mind. As Masons and leaders of our communities, families, and businesses, we need to keep looking for what we have in common, as opposed to what makes us unique and different from everybody else. Our competitive society associates the term ‘differentiator’ with what makes you better than the rest, a concept very often confused with that of *'leadership'*. In a collaborative environment, such as a Masonic lodge, and supposedly human society, we should leave ‘*differentiators*’ behind us, and look for ‘*connectors*’, or what makes us belong to the same group.

A common denominator between two numbers is always lower than the highest denominator of one of the two.[1] That means that to connect with someone else we need to lower our expectations, disarm our defences, stop comparing and judging, and hope that the other person will do the same. These conditions for success have been mathematically proved in the fields of Number Theory,

[1] Unless we have a prime number, in which case the only common denominator is One or “Unity” (a Pythagorean term). One needs to study the liberal science of arithmetic to fully appreciate the divine beauty of these numbers, their mystery still unrevealed to modern science and their rich philosophical implications.

Optimization and Game Theory, which are employed today to develop complex negotiation models used in international trade, politics and diplomacy. Even primitive animals and plants follow these protocols when interacting with others, else they would not survive.

Plato, Socrates, and the scholars of antiquity intuitively knew about the relationships between all sciences, for they were also generalists and could read the *"Book of Creation"* – Nature.

They understood that all sciences communicate how God's creation works, as they all talk about the same fundamental things.

The collaboration/connector way of thinking is critical to establish dialogue and cooperation, and is often forgotten by Masons and non-Masons alike, it is quite hard to forget that we do not have to be better than everybody else, all the time. Human nature is judgemental and defensive. Once we are allowed to leave the status of a mere apprentice and we have spent enough time humbly studying the arts of logic and debate, examination and analysis, we become able to think beyond the small horizon of our current position in our lodges, our day-to-day problems and the tiny self-centric universes we live in. Beyond acquiring deep specializations, we improve our ability to control our emotions with the tools of reason.

The Liberal Arts and Sciences and the Masonic teachings enlighten the same things. They communicate the same ancient knowledge and urge their students to better known themselves and the universe around them. As Masons, or *"good men being made better"*, we find the Liberal Arts and Sciences to be important tools that help us shape the rough ashlar into the perfect shape.

- Source: Mackey's Encyclopaedia of Freemasonry

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To conclude: Why should we study the Liberal Arts and Sciences?

We often question the value of studies that don't offer a direct track to employment. But a broad-based liberal arts education does more than just prepare you for a job. It lays the foundation for a well rounded education no matter what stage of your life.

Whether you choose to read a poem, peer into a microscope, act in a Shakespeare play, decipher a medieval manuscript, or unravel the mysteries of the human brain, you learn more than facts: you learn to think independently and make sound judgments. You expand your horizons, discover new perspectives, and acquire the tools to defend your point of view.

To be liberally educated is to be transformed. A liberal arts education frees your mind and helps you connect dots you never noticed before, so you can put your own field of study into a broader context. It enables you to form opinions and judgments, rather than defer to an outside authority.

The foundation for a liberal arts education lies in a course of study that combines both breadth and depth.

Every field of study is but one of many ways of partitioning knowledge — a part of a much greater whole. A liberal arts education bridges existing divides by offering a curriculum that creates coherence and integrity in your intellectual experience.

Universities offer degrees in a chosen field. But life is not divided into majors. Then why should an educational experience be anything less than a unified whole?

No matter how advanced our society, we never lose the need to reflect on life, to distinguish good from evil, justice from injustice, and what is noble and beautiful from what is useful.

The tradition of asking questions and reflecting on such issues has its origin in the classical thought of Greek philosophers. But it was during the Age of Enlightenment that the scope of liberal arts expanded and turned into a core curriculum that still comprises the broad range of humanities and sciences that provide the moral compass the ancient Greeks sought and that we still strive for.

Adapted from papers published by the University of California.

"The value of an education in a liberal arts college is not learning of many facts but the training of the mind to think something that cannot be learned from textbooks."

Albert Einstein.

The Front Cover:

This painting was produced by Herrad of Landsberg, a 12th century nun and abbess of the Hohenburg Abbey in France. She was born about 1130 in the castle of Landsberg, the seat of a noble French family. When she was 35, Herrad had begun the work for which she is best known, the Hortus Deliciarum (The Garden of Delights), a compendium of all the sciences studied at that time. In this book Herrad delves into the battle of Virtue and Vice with vivid visual imagery.

Philosophy – the Queen of the Arts At the centre of the inner circle we find lady Philosophy, to whom all the arts give service. She sits as queen of the arts, with philosophers Socrates and Plato under her feet. In the upper right corner we read, "Seven fountains of wisdom flow from Philosophy, which are called the seven Liberal Arts. The Holy Spirit is the inventor of the seven Liberal Arts, which are: Grammar, Rhetoric, Dialectic, Music, Arithmetic, Geometry, Astronomy."

Arranged around this interior circle, like spokes of a wheel, are the liberal arts:

Grammar: Grammar was called by the ancients the Janua Artium, the "gateway of the arts". Grammar holds a book and a rod (scopae) probably for punishing young students. Above Grammar, we read *Per me quivis discit, vox, littera, syllaba quid est*. Through me, everyone can learn the meaning of words, syllables, and letters.

Rhetoric: Rhetoric carries a tablet and a stylus. Above her ,we read *Causarum vires per me, rhetor alme, requires*. Thanks to me, my dear orator, your speeches will move the listener.

St. Augustine (Augustine of Hippo) stressed the importance of Rhetoric as a weapon to defend goodness and truth from the attacks of falsehood and lies: "Who will dare to say that truth is to take its stand unarmed against falsehood? Since the faculty of eloquence is available for both sides... [i.e. Good and Evil] why do not good men study rhetoric to engage it on the side of truth?"

Dialectic: Dialectic, or Logic, points, perhaps to a debater, with one hand and holds a barking dog's head in the other. Some believe that the dog was used in opposition to the wolf typically associated with heresy. Above Dialectic it is written *Argumenta sino concurrere more canino*. My arguments follow each other rapidly, like the barks of a dog.

Music: Music is holding a harp, flanked by a lyre and an organistrum. Above her, we read, *Musica sum late doctrix artis variatae*. I am Music and I teach my art with the help of various instruments.

Arithmetic: Arithmetic holds a knotted string, an early form of abacus. Above her, we read *Ex numeris consto, quorum discrimina monstro*. I have faith in numbers and I show how they are related to each other.

Geometry: Geometry, the art of measuring objects at rest rightly is seen holding a yardstick and a compass. Above Geometry, we read *Terrae mensuras per multas dirigo curas*. With precision I measure the earth.

Astronomy: Astronomy holds in her hands a sort of magnifying glass or mirror and is observing the stars. Above Astronomy, we read *Ex astris nomen traho, per quae discitur omen*. I owe my name to the celestial bodies and I predict the future.*

** The divinatory/astrological/zodiacal use of astronomy at the time, even included Catholic scholars.*

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